Water Works and Sewerage

Vol. LXXVIII JANUARY, 1931 No. 1

Water Supply Increased by Use of Infiltration Gallery

How Small Colorado City Secured Additional Water by Constructing a 2,800-Ft. Perforated Collection Line for Underground Flow

By A. A. WEILAND

Weiland Engineering Co., Pueblo, Colo.

THE town of Castle Rock, Douglas County, Colorado, had been until recently inconvienced by an insufficient water supply which occasionally carried silt and was generally unsatisfactory.

This supply had been accumulated by vitrified tile in an underflow gathering system about 4½ miles above the town at Plum Creek, and held in a concrete collection well, from which it was carried to the town by a wood stave pipe 8 and 10 in. in diameter.

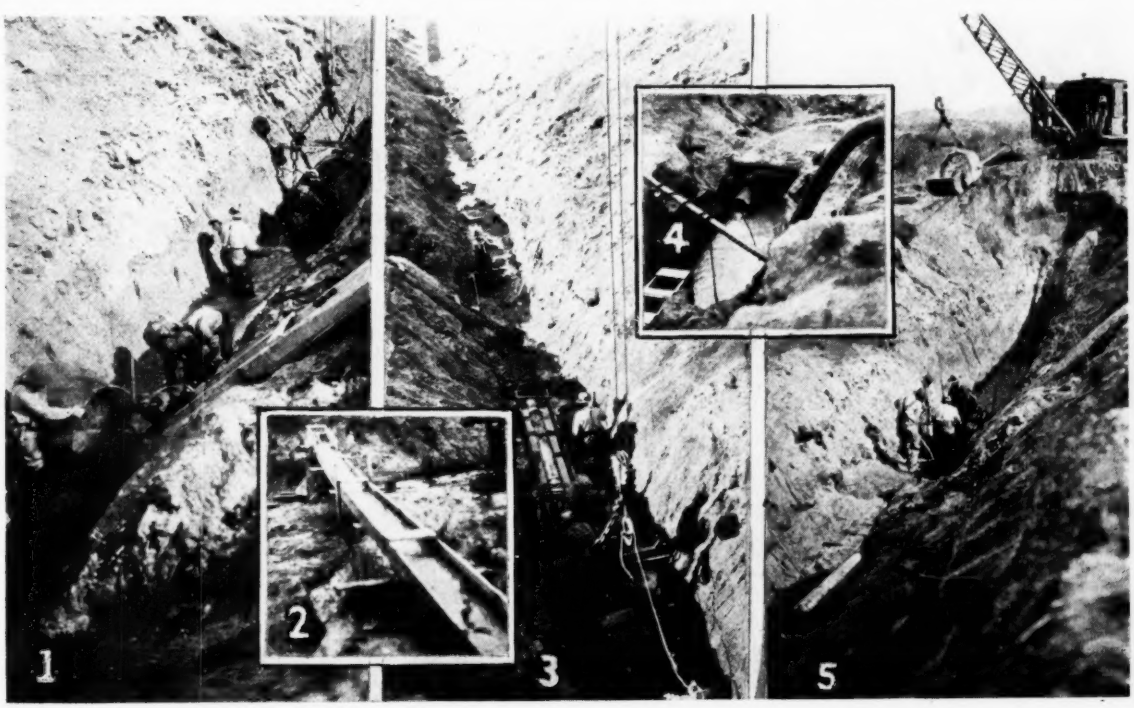
Why Original System Failed.—Failure of this system was attributed to two conditions: The first being that the gravel formation in which the collection pipe was laid was filled with clay and other earthy material which prevented the infiltration of water; and the second because the pipes were not laid sufficiently deep to collect any great amount of water.

At times, when the surface supply was low in Plum Creek, the underground collection system secured but little underground water. To supplement the underground supply a surface connection had been made between Plum Creek and the concrete intake well. This method of getting the needed additional water allowed considerable sediment to enter the town mains.

A survey with a view to remedying conditions by providing a supply of water amounting to 400 to 600 gal. per minute, indicated that some further development of Plum Creek would be necessary.

The first investigation had been made on Plum Creek about ½ mile above the location of the concrete collection well. A large deposit of good sand and gravel was found at this point in the creek bed and it was believed that this area would be an excellent one for the construction of an underflow as the sand was deep and of the proper composition to make a fine infiltration bed.

A 12-in. well with perforated casing was to have been sunk in this bed to a depth of 30 ft. by a driller em-



Constructing a 2,800-Ft. Perforated Collection Line for Increasing Water Supply of Castle Rock, Colo.

1—Workmen covering a section of perforated pipe with graded gravel on the infiltration system of Castle Rock, Colo. 2—Flow of water secured after only a part of the 2,400 ft. of perforated corrugated pipe had been installed. 3—The wooden form in place around the pipe during installation and before the graded gravel had been placed around it. The form kept out sand until the gravel had been poured around the pipe by means of the chute seen in the middle foreground. One of the concrete manholes is visible in the distance. 4—Another view of the flow developed when the system was only partially complete. This picture was taken near the concrete collection well. 5—Workmen installing a section of the Armco perforated pipe in a deep fill. All excavations on the line were made by the dragline shown here.

ployed by the town, to determine the depth and flow of ground water. However, difficulties were encountered with the equipment and the well was never sunk to the required depth. Pumping in the well as it was finally constructed brought out only 10 gal. per minute.

Underflow Development Undertaken.—After further study and discussion with the engineers, it was decided that an underflow development should be undertaken which would extend from the concrete well, up Plum Creek for about ½ mile to the gravel bed in which the test well had been sunk.

The quality of the water was, of course, a major consideration; and the town council was willing to spend the cost of the proposed improvement to get a purer supply even without assurance of any increase in quantity.

It was the belief of engineers that a considerable additional supply would be encountered by the development of a proper system of underground collection pipes.

General Plan of Development.—The general plan of this underground system of collection pipe was to begin at the concrete intake well and lay the pipe on such a grade as was necessary to carry the required flow, but gradually laying the pipe to greater depths as it was extended. The profile showed that it would require a 12-in. pipe to discharge 600 gal. per minute and that the lower end of this pipe at the concrete intake well would be 8 ft. in depth and at the upper end 24 ft. in depth.

The problem immediately arose as to what kind of pipe to use. After an exhaustive study it was determined that a corrugated metal pipe of 16 gauge material would adequately stand the external pressure. Armco iron pipe was specified. All but the first 600 ft. laid was perforated by punch on top in order to permit the inflow of the water. About 2400 ft. of 12-in. and 400 ft. of 15-in. pipe were employed.

As the work of laying the pipe progressed upstream various ground materials were encountered but none of them were water-bearing in the sense of the entire body being filled with water. At places along the excavation a small stream would be encountered always above a certain layer of clay and at depths of about 8 to 10 ft. Below this layer of clay the material was mostly dry. This condition continued until a depth of about 22 ft. was reached when some water in the lower sands began to appear.

The Collection System.—After about 2400 ft. of pipe had been laid, a considerable amount of water had been developed, but not as much as was wanted. At this point a cross line of 15-in. perforated pipe, 400 ft. long, was laid at right angles to the axis of the creek. In excavating for the manhole on this line, a depth of 28 ft. was required and upon reaching this depth about 3 ft. of hard clay was gone through. When a hole was made through this layer of clay, water from below began flowing up into the trench under considerable pressure. This water was much colder than any encountered before.

In order to determine the extent of this flow a test well was sunk about 9 ft. below the trench depth. The water came out under pressure. As a result of this flow several 4-in. perforated pipes were driven about 9 ft. below the trench depth at about 15-ft. intervals. Each of these wells flowed about 20 gal. per minute and delivered its water directly over the 15-in. perforated pipe.

With the water developed from the wells and the flow developed in the laying of the 12 and 15-in. pipe, the full capacity of the pipe line of about 600 gal. per minute was secured.

The accompanying illustrations show several stag on the development work.

Construction Features.—The water encountered the shale bed as the pipe was laid, occasionally impede the workmen. In order to keep the working trench free from water as possible the dragline bucket wa used for a temporary dam. If allowed free flow th water caused caveins around the mouth of the pipe an so clogged it up. Illustration No. 1 shows the draglin bucket in the trench as a dam while workmen are cov ering a section of the pipe with graded gravel.

In No. 2 can be seen the flow of water which was de veloped when only part of the perforated pipe had bee laid.

In order to keep out encroaching sand until after th graded gravel had covered the pipe it was necessary t place a wooden form around the pipe. The form i place can be seen in No. 3. The movable wooden chut down which the graded gravel was poured can be seen beyond the end of the pipe. In the distance is one of a series of manholes which were placed 400 to 600 ft. apart along the pipe line.

Another view of the amount of water developed before completion of the installation is shown in No. 4 which was taken near the concrete intake.

Workmen are shown installing a section of pipe under what was to be one of the deeper fills, in No. 5. All excavation work was done by the dragline shown in the background.

Preventing Clogging of Pipe with Quicksand.—Quicksand in suspension in the water, caused considerable trouble during installation by stopping up the pipe. The contractor, to protect himself and provide a means of cleaning the pipe before placing it in service, threaded a ¾-in. rope through the pipe from one manhole to the next. When stoppage occurred, two or three men on each end of the rope would pull it in alternate directions to loosen the sand and start the flow. It was important that the pipe be kept open during installation in order that the water might be drained off as it gathered. This need for cleaning the pipe was only a temporary one, however, and after the gravel backfill was placed, no more difficulty was encountered because of quicksand.

After the graded gravel had been placed over the pipe it was possible to find gravel sufficiently clean and of proper size in the ditch banks to be laid over as an intermediate fill layer. The remainder of the backfill was placed by dragline.

This improvement was planned by the Weiland Engineering Co., of Pueblo, Colo., and John F. Rhoads was resident engineer. Construction work was done by Platt Rogers, Inc., also of Pueblo. The perforated Armco pipe was furnished by the R. Hardesty Manufacturing Co., Denver, Colo.

Officials of Castle Rock who endorsed this plan are: Mayor Harold A. Senter; George Nickson, H. G. Johnson, J. H. Kroll, P. S. Miller, Jr., J. A. Van Lopik and C. G. Towne, Councilmen; E. G. Bresslow, treasurer; E. S. Triplett, clerk; and L. C. Tuggle, water works superintendent.

MONTREAL HAS TECHNICAL ADVISORY COMMITTEE.—A technical commission of experts to advise the city and the Public Works Department on all public works and improvements has been created in Montreal. The commission will be given the aid of the Town Planning Commission, and all projects for city improvements will be passed upon by the new body.

Reclamation of Treated Sewage

The Experimental Sewage Treatment Plant of Los Angeles, Calif., and Some of the Results That Have Been Obtained

By R. F. GOUDEY
Sanitary Engineer, Department of Water and Power, Los Angeles, Calif.

THE Bureau of Water Works and Supply of the city of Los Angeles, under the direction of H. A. Van Norman, Chief Engineer and General Manager, and Dr. Carl Wilson, Director of Sanitation, has for several years been conducting a comprehensive study of reclamation and for the past six months has been actually demonstrating on a working scale that sewage can be treated with adequate safety and can be reclaimed without offense. It is interesting to note that not one of over five hundred visitors to the plant has voiced any criticism of it and all have apparently been impressed with the feasibility of reclamation.

Methods Being Studied.—The possible methods of reclamation which the department is studying include: complete treatment for direct augmentation of reservoir supplies; replenishment of underground water supplies with sewage treated to the proper degree for the different spreading grounds under consideration; substitution of treated water for irrigation supplies; utilization of treated sewage for the development of new agricultural areas and production of a water suitable for various industrial purposes. Any of these methods can be carried out far more safely and with less psychological objection than is the case with the cruder methods of reclamation of the east.

The present study at the reclamation plant of the department is that of replenishing ground water levels above infiltration gallery locations. This method of reclamation has very distinct advantages over discharging untreated sewage into rivers used for domestic supply in that the sewage, in the first place, is given high grade sewage treatment before discharge onto beds; second, the natural purification in sand beds and through underground journeyings is far greater than provided in the natural self-purification of rivers; third, the identity of treated sewage is annihilated more effectively; fourth, dilution is far greater; and, fifth, the time of travel instead of being measured in days is increased to many months.

Sewage and Sewage Treatment.—Many people have the "specialist" idea of sewage reminiscent of earlier days. In the modern water carriage system the human wastes are automatically diluted 2,500 times with water. Such sewage at its worst is 99.96 per cent water. It is the dirtied water supply and is a by-product of the waterworks just as power is a by-product where it is developed from water supply. Power instead of being wasted is commercialized. Sewage has the same possibilities.

Nature has been reclaiming used water and for countless eons has been returning it for re-use. Reclamation simply speeds up this natural function. It uses Nature's forces of selfpurification, improves and harnesses them under laboratory control where the entire cycle is speeded up and accelerated. By laundering the sewage to remove dirt and dangerous material, clear, clean and safe water can be produced. When one's shirt becomes dirty it is washed instead of being discarded. Why not the same with sewage?

Water and sewage have been blamed by the laymen as the cause of every existent disease and yet only a few of the almost obsolete diseases such as typhoid, para-typhoid, dysentery and cholera are water-borne. Water purification as now developed affords ample protection against them. Sewage purification even of mediocre types gives complete and positive protection against pathogenic organisms and in no instance has any epidemic been traced to the effluent from any so-called high grade sewage treatment plant. Certainly combinations of sewage treatment and water purification give ample factors of safety ensuring positive protection to public health.

That sewage itself can be completely treated for domestic purposes is witnessed by several cities on the Ohio River and a number along the Ruhr River in Germany, where, during low river stages, more water has been diverted than present at normal dry weather flow because of the added increment of sewage. During these periods the bacterial count of the raw water has been identical with crude sewage. Yet, in these cases water purification plants alone produced water complying with the United States Treasury Department standards, even though the raw waters were far inferior to the effluents from high grade sewage treatment plants.

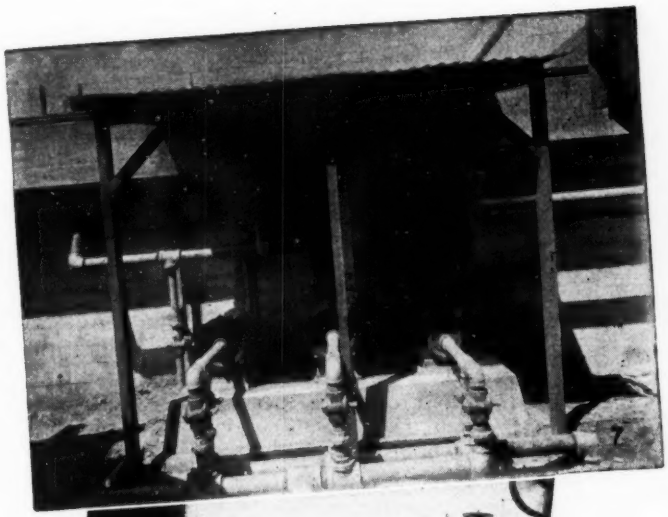
Each scheme of reclamation requires its own degree of sewage treatment and in no case should the present policy of puting in plants to just "get by" and meet minimum standards be tolerated. Likewise, all uncertain steps in treatment should be fully worked out and only that type of plant which really meets all requirements should be constructed.

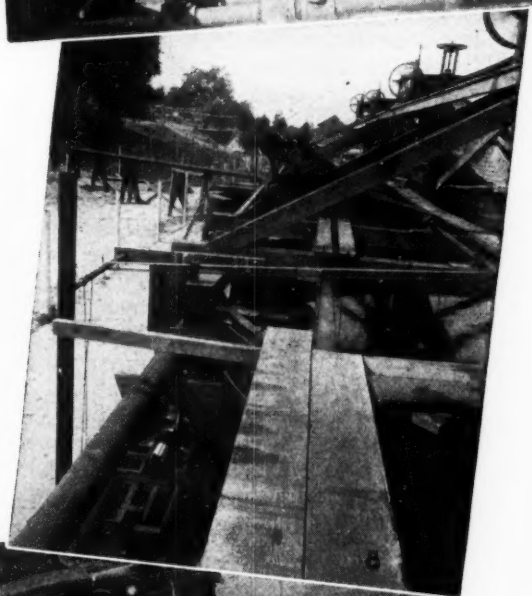
The Model Plant of Los Angeles.—No one has developed this phase of reclamation and the Los Angeles Bureau of Water Works and Supply pioneered by placing in continuous operation on May 12, 1930, a model sewage treatment plant purposely designed really to treat sewage, work out refinements and overcome many hitherto unsolved steps in treatment. The plant is particularly designed to use mechanical equipment to the greatest possible extent, to simplify and reduce the cost of operation and to carry treatment further than ever before attempted by anyone. This plant is experimental only insofar as improvements in sewage treatment are concerned, but it is a demonstration working plant to determine accurate costs both of installation and operation in the actual successful reclamation of sewage. It is the first installation on a working scale of a high type of treatment plant which is continuously producing from sewage a safe drinking water strictly complying with an even exceeding all standards. Samples of water in long Nessler tubes have less color and turbidity than distilled water and actually have a more sparkling appearance. These statements are not based on talk or theory but are of actual accomplishment.

Details of Los Angeles Plant.—The sewage purification plant operated by the Department of Water and Power of Los Angeles consists of four stages of treatment: clarification, stabilization, filtration and spreading on disposal beds. Clarification and disposal of sludge takes place in a separate sludge digestion plant; stabil-

1. General View—Aeration Tanks in Center, Filtration Works at Left, Clarifiers and Digester Behind Aeration Tank, Sludge Beds at Right. 2. Same as 1 Except Sludge Beds on Right Are Cut off. 3. General End View. Inlet Sewer on Trestle at Left, Filter Plant in Foreground, Final Effluent from Activated Sludge Plant at Lower Left Hand Corner. 4. Cipolletti Weir Outlet System for First Clarifier. Note Type of Speed Reducer on Aeration Tanks 5. Imhoff Paddles in Aeration Tank Before Filling. Filtros Plates Were Installed in 5 in. Channel Shown at Left of Horizontal Shaft. 6. Aeration Tanks and Two Final Clarifiers. Wallace and Tiernan Chlorinators Are Shown on Top on the Clarifier in Center of Picture. Automatic Sampler Is Seen in Trough in Lower Rigth Hand Corner to Right of Water Hydrant. Dorr Sludge Pump at Left

ADVERTISING PAGES REMOVED





7. Battery of Sludge Pumps with Suction and Discharge Manifolds. 8. Adjustable Final Clarifier Weir in Center. Recording Weir Gauge and Final Activated Sludge Effluent Weir in Lower Left Hand Corner. Influent Is Elevated Pipe at Upper Left. 9. Filtration Works. Inlet Is Horizontal Pipe Entering from Right. Ferric Chloride Machine Sets Over Sewer Pipe Feeding Ferric Chloride. Small Vertical Pipe at Right Is Sludge Return Line. Paddles Are in Mixing Tank. Square Filter Is Sand Filter. Round Tank Is Activated Carbon Filter. Final Product Is Shown in Tile Box in Center. 10. Close Up of Sand Filter, Rate Control Box and Final Product in Tile Box. 11. Final Sand Beds, Float Recorder on Right for First Bed, Evaporation Pan at Right, Venturi Flume in Foreground. Test Wells Shown on Every Other Dyke. 12. Electric Panel and Meters for All Uses, Gas-Electric Generator in Center. Hot Water System on Right. Digester Temperature Recorder in Upper Right

ization occurs in an activated sludge plant; filtration is secured by chemical coagulation, sedimentation, sand and carbon filtration; and final disposal is on sand beds where ground water is replenished. The capacity of the entire plant is 200,000 gal. per day except for the filter plant which is one-third of that amount.

The separate sludge digestion plant settles the crude sewage in Dorr clarifiers for two hours, removing settleable and floating material. The fresh sludge and concentrated excess activated sludge is pumped to a covered and heated digestion tank where all solids entering the plant finally succumb to gasification, liquification and humification. The digested sludge is removed onto drying beds and produces when dry, a fertilizer of about the nitrogen content of barnyard manure. Experiments with conditioning and vacuum filtration of digested sludge indicate that in the future there will be no need for any sludge drying beds. Overflow liquor, a serious problem in plants of this type, has been reduced over 85 per cent in volume by concentrating sludge before pumping it to the digestor and withdrawing digested sludge simultaneously with the pumping in of new sludge. Gas evolved in the process is used for power development and engine cooling water is employed in heating the digestion tank. It appears that sufficient power can be developed to operate the entire activated sludge plant, greatly reducing its cost of operation.

The settled water passes to the activated process which removes practically all suspended matter and produces a fairly clean clear and odorless water. The procedure is that of adding activated sludge to settled sewage and after aerating the mixture for a proper period it is allowed to settle. The biological life and colloidal characteristics of the activated sludge are such as to remove colloids and suspended solids after prolonged intimated contact so that when the sludge is permited to settle clear water overflows at the top. The settled sludge is re-circulated continuously and when an excess is built up it is intermittently withdrawn for disposal in the separate sludge digestion plant.

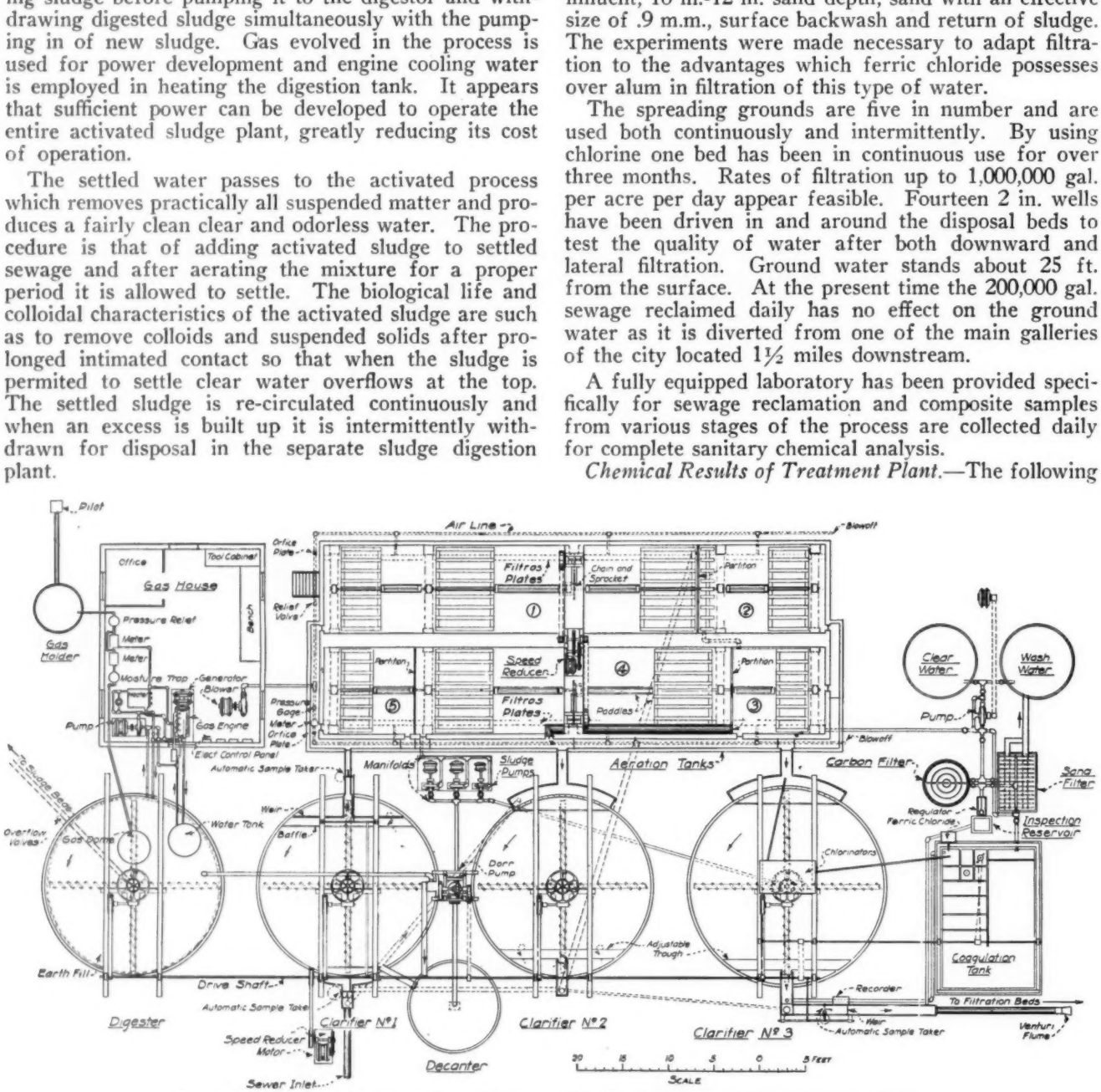
The aeration tanks are equipped with Imhoff paddles which effect large savings in compressed air ordinarily used at such plants. Experiments with various percentages of sludge return, aeration and re-aeration periods, multistage treatment, double sedimentation and an addition of enzymes are under way and it is already indicated that better than customary performances can be obtained at less than the usual cost of operation.

The filtration plant consists of: super-chlorination, with Wallace and Tiernan equipment to remove phenols and odors and to oxidize organic matter; coagulation with ferric chloride and returned sludge in mixing tanks to remove iron, color, turbidity and any traces of hydrogen sulphide, if present; sedimentation, to remove the greater portion of the settled floc; filtration through sand, to produce a clear water; and, finally, filtration through Darco activated carbon to remove residual chlorine and any final color. Experiments include proper mixing methods for ferric chloride, revision of filter equipment using manifold jet inlets for influent, 10 in.-12 in. sand depth, sand with an effective size of .9 m.m., surface backwash and return of sludge. The experiments were made necessary to adapt filtration to the advantages which ferric chloride possesses over alum in filtration of this type of water.

The spreading grounds are five in number and are used both continuously and intermittently. By using chlorine one bed has been in continuous use for over three months. Rates of filtration up to 1,000,000 gal. per acre per day appear feasible. Fourteen 2 in. wells have been driven in and around the disposal beds to test the quality of water after both downward and lateral filtration. Ground water stands about 25 ft. from the surface. At the present time the 200,000 gal. sewage reclaimed daily has no effect on the ground water as it is diverted from one of the main galleries of the city located 1½ miles downstream.

A fully equipped laboratory has been provided specifically for sewage reclamation and composite samples from various stages of the process are collected daily for complete sanitary chemical analysis.

Chemical Results of Treatment Plant.—The following



General Details of the Experimental Sewage Purification Plant of Los Angeles, Calif.

Table of Chemical Results Reclamation Plant

	Sewage Crude	Treated Sewage—Settled	Treated Sewage—Stabilized	Treated Sewage—Fully Treated	L. A. water—Untreated—Aqueduct	L. A. water—Untreated—Gallery	Per cent removal sewage to fully treat sewage compared with L. A. aqueduct
B. Coli	100,000	50,000	1	0.00	0.05	0.00	100+
Suspended Solids	418	77	3.2	0.0	6.0	0.0	100+
Turbidity	440	.....	8.3	0.2	25	0	100+
Oxygen Demand	515	222	9.1	0.99	1.25	1.0	100+
Oxygen Consumed	180	46	8.3	4.1	3.5	1.2	99.7
Organic Nitrogen	48.1	37.3	5.08	2.25	1.3	0.5	99.8
Free Ammonia	50	20	1.0	0.65	0.25	0.20	99.2
pH	6.8	6.6	7.0	7.1	7.3	7.2	.....

table gives averages for several hundred samples on a few of the most important tests.

These analyses clearly demonstrate that the treated sewage is better than aqueduct water and about the same as gallery water. Minerally the treated water is just as acceptable. These tests include analyses of samples taken during the peach and tomato packing period when the plant handled the wastes from 150 tons of peaches packed per day. During a month of this period the settleable solids averaged 600 p.p.m. and the B.O.D. was over 800 p.p.m. The entire plant was put to a severe strain and the results above given are on this account all the more remarkable. During the winter season analyses will probably show the quality of the fully treated sewage water to be equal to or better than gallery water. Furthermore, it has only been during October that any attention has been given to the filtration plant in order to get more efficient results. The removal of 99.2 per cent of free ammonia means that there is left in the treated sewage less than 0.05 ounces of nitrogen for each 1,000 gal. In 12 hours time the raw sewage becomes a good water with no B. coli in 50 cubic centimeters, with a turbidity and oxygen demand of less than 1, and no trace of suspended solids. Upwards of 300 of the 500 visitors to the plant have tasted the treated water and many have drunk it liberally without any disastrous effects.

Costs.—Accurate records are being maintained in order to determine the costs of plants of 1 m.g.d., 10 m.g.d. and 25 m.g.d. designed on the same basis of operation as the demonstration plant. The costs for the larger plants are determined after a complete and detailed design has been made enabling the depreciation and maintenance of the smallest piece of equipment to be figured. The installation cost for a 25 m.g.d. plant, including separate sludge digestion, activated sludge and chlorination is $1,500,000. The cost of adequate operation including power, labor, chemicals, depreciation, maintenance, research, miscellaneous items and contingency is one and one-half cents per 1,000 gallons. The installation cost and operation of the filtration units has not yet been fully worked out. The added installation cost may be $10,000 per mg. capacity and the operation might reach one-half cent per 1,000 gal. It is interesting to note that the net cost of treating sewage at Pasadena, exclusive of interest and bond redemption, is four cents per 1,000 gal. The cost of ocean outfall maintenance and adequate treatment for ocean disposal is 1½ ct. per 1,000 gal. These figures do not include interest or bond redemption which, for reclamation, would be less than 1½ ct. per 1,000 gal.

Reclamation.—At the present time the actual demonstration by the Department of Water and Power of Los Angeles is the replenishment of ground water, simply because it works in with the experiments on sewage treatment.

Reclamation is a problem of great magnitude in which a number of difficulties have to be overcome. It involves many lines of investigation and it would be premature at this time to outline and give out cost summaries of schemes which have already been worked out. It is felt, however, that a good start has been made on a problem so important to the future welfare of Southern California.

Acknowledgment—The foregoing is an abstract of a paper presented before the California Section of the American Water Works Association.

▼

New Meter Rates for Cleveland, O.

The City Council of Cleveland, O., on Dec. 29 passed an ordinance for new water meter rates, which are to become effective on April 8. The ordinance provides for the following minimum charges for each 6 months for customers within the territorial limits of the city:

For a ⅝-in. meter, $3.00.
For a 1-in. meter, $5.00.
For a 1½-in. meter $12.00.
For a 2-in. meter, $20.00.
For a 3-in. meter $42.00.
For a 4-in. meter, $75.00.
For a 6-in. meter $170.00.
For an 8-in. meter $300.00.

This minimum charge will be collected for supplying water to each customer who may make use of not more than 1,000 cu. ft. of water semi-annually.

The rate for all water in excess of 1,000 cu. ft. by any customer within the territorial limits of the city of Cleveland, will be at the following schedule, based on semi-annual calculations:

For the first 49,000 cu. ft., for each six months, in excess of 1,000 cu. ft. of water, 85c per 1,000 cu. ft.

For the next 450,000 cu. ft., for each six months, 70c per 1,000 cu. ft.

For all water used in excess of 500,000 cu. ft., for each six months, 60c per 1,000 cu. ft.

▼

Elevated Tank Competition Has 691 Entries

The elevated steel tank competition which is being sponsored by the Chicago Bridge & Iron Works upon which the entries closed Dec. 1st, has created considerable interest, judging by the number of applicants. Six hundred and ninety-one architects, engineers and draughtsmen have registered their names with Albert M. Saxe, the professional adviser and are now at work on their designs which are due on March 1, 1931.

The contestants are residents of 16 countries, Germany ranking next to the United States in number of entries with 40.

Announcement of the awards of eight prizes totaling $4,000 will be made soon after the close of the contest.

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by A. ELLIOTT KIMBERLY, Associate Editor
Consulting Sanitary Engineer, Columbus, O.

Storm Standby Tanks

Storm standby tanks have frequently been used abroad, particularly in England and Germany, but to date very few have been built in North America. A relatively large plant of this type, costing slightly in excess of $500,000, is at present under construction in Columbus, O., and is the first installation in the United States. The evident increasing importance of the storm sewage disposal problem in connection with sewage treatment, prompts this brief review of current English, German and Canadian practice.

The problem generally arises in cases where sewage treatment is required for the dry weather flow in combined sewers. Storm standby tanks may also be useful where it is necessary to prevent the deposition of sand, grit and detritus in a receiving stream, even where no dry weather flow treatment is demanded and finally to reduce the cost of long outfall sewers by erstwhile storm flow retention, which, obviously, materially reduces required sewer capacities.

The first flush during storms contains, of course, large quantities of street washings, grit, sand and considerable organic matter. If such storm sewage is permitted to discharge through storm overflows, the receiving stream has frequently, as yet, not itself been affected by the storm and hence too limited dilution exists to provide proper assimilation and dispersion. The result may be a reduction in the effective cross section of the receiving stream, the formation of objectionable sludge deposits and the presence of unsightly floating matters.

By providing storm standby tanks, operated in conjunction with sewage treatment works, the entire program of treatment is thus rounded out and storm sewage freed from the greater part of its suspended matters, reaches the receiving stream only under such high dilution that objectionable conditions are entirely eliminated.

As the storm flow decreases, moreover, the sewage and the solid matters, temporarily retained in the storm tanks, again enter the intercepting sewer and receive the full treatment afforded at the sewage works.

English Practice

In England, requirements for the treatment of storm water were standardized by the Royal Commission on Sewage Disposal in the fifth (1908) report. The commission found that the injury to rivers by the discharge of storm water, was chiefly due to an excessive quantity of suspended solids of a type that can be very rapidly removed by sedimentation.

In view of these facts, the commission adopted certain regulations, which are the present basis of storm water treatment design in England. These regulations provide two or more special standby tanks, which must be kept empty at sewage treatment works, for receiving the excess storm water, which cannot effectively be passed through the ordinary tanks. The commission further concluded, that during storms, the rate of flow through the usual preparatory devices may safely be increased to 3 d.w.f. Further, any overflow of excess sewage should take place only after the sewage has passed through and has completely filled these special standby tanks. It was further pointed out, that no special storm filters should be provided, as was former practice, but the ordinary filters or oxidizing devices, should have sufficient capacity to provide proper treatment for all of the sewage, which under given conditions must receive treatment before entering the receiving stream.

Current English practice, with respect to storm overflows, is described in a textbook[1] by T. H. P. Veal, Lecturer in Civil Engineering, at the University of Birmingham, published in London, in 1927.

On combined systems, sewage treatment works are designed to treat three times the average daily quantity of domestic sewage, usually termed the "dry weather flow" (d.w.f.). Two or more special standby tanks are provided to receive storm water in excess of 3 d.w.f. and the overflow from such tanks, may be discharged into the receiving stream.

According to Veal, storm standby tanks are usually located above the treatment works and are filled from overflow weirs, built in the side of the outfall sewer or in the channel connecting the grit chambers with the main treatment plant. The velocity in storm tanks should not exceed 0.1 ft. per second. The tanks are usually 120 ft. long. It is further customary and important according to Veal, that storm tanks be located below the screens, so that screened sewage only will reach the tanks. The tanks should be two or more in number and their capacity should be not less than one-fourth the dry weather flow. They should be arranged so that when full, they will operate as continuous flow tanks with provisions for emptying and cleaning and particularly for maintaining the tanks empty during dry weather.

Raikes[2] devotes a chapter in his treatise on sewage disposal to storm overflows and storm water treatment. While the Veal data perhaps more accurately reflect current English views in storm sewage disposal, yet practice in England has apparently not materially changed since the publication of the Fifth Report of the Royal Commission on Sewage Disposal in 1908. Abridged comments from Raikes' discussion of the subject therefore appear of interest.

Raikes states properly to compare the efficiency of a sewage treatment works from the river pollution standpoint, it is not only necessary to consider the degree of modification of the final effluent, but also the question of untreated storm water discharged into the receiving stream. Although a sewage treatment plant

may produce a very satisfactory effluent, serious pollution may still take place through inadequate provision for the treatment of the putrescible organic matter in the storm water.

Formerly, the Local Government Board required treatment of sewage at a sewage works up to 3 d.w.f. and from 3 to 6 d.w.f. on special storm beds. It was doubtless because of the impossibility of maintaining such infrequently used filters at highest efficiency that the Royal Commission, as well argued, also by Raikes, proposed storm tanks or flow equalizing storage reservoirs as a more practical and effective plan.

As to storm tank design, Raikes states that such tanks should be so designed that their stored sewage may gradually be discharged into the sewer system, pumping station or treatment works, as soon as the flow decreases below the maximum volume which can be handled by the plant. Such equalizing tanks, he continues are usually arranged with float controlled outlets which maintain the rate of discharge from such tanks, independent of the varying depth of water therein.

It is further pointed out that a similar result could be secured by providing automatic controlling devices on the outlets of the main plant settling tanks, thereby temporarily increasing the storage by increasing the effective depth of the tanks. Such an arrangement, he states, was used at Barrhead, effecting a storage of about 0.33 d.w.f. This plan did not prove satisfactory owing to the fluctuating water level in the tanks and it further prevented the use of tank outlet weirs.

Raikes suggests storm standby tank capacities of 0.5 d.w.f. By such provisions, the operation of storm overflows will be deferred inversely with the rate of flow and under a flow of 6 d.w.f., the operation of storm overflows is prevented for a period of from 3 to 4 hours. Such tanks, he points out, will permit strong storm sewage to be handled at the sewage treatment works without excessive loading of either preparatory devices or oxidizing units.

German Practice

German views on storm standby tank design are quite fully covered by Imhoff in "Fortschritte der Abwasserreinigung" (1926), a condensed translation of which follows.

In England, the capacities of storm tanks are still based upon the requirements of the Royal Commission on Sewage Disposal, according to which, settling tank capacities shall provide for 6 hours and storm tanks for an additional 12 hours or a total tank capacity of 18 hours. When the rain is over, the storm tanks are emptied by pumping, so that they will be ready for the next rain. Under these very severe regulations, it is evident that storm sewage very rarely reaches a receiving stream.

In Germany, settling tanks generally have a capacity of, from 1 to 2 hours, on a dry weather flow basis. The difference between English and German practice is so great that investigations on storm tank operation were made some years ago by the Ruhr River Board, at a small plant near Essen, where Mannes patented storm tanks are in operation. This plant serves a suburb of Essen, with a tributary population of 20,000 and a contributing drainage area of nearly 200 acres. The capacity of the storm tanks is about 48,000 gal.

Automatic recording apparatus was used during the investigations, which continued throughout the year 1913. The results were published by Engberding[1], who shows that in this particular case, the dry weather flow for the year was about 106 and the storm flow, about 82 million gal. or about 75 per cent of the annual dry weather flow.

Other interesting facts, developed during these studies, are as follows:

	No. of Times	No. of. Days	Time in Hours	Per Cent Annual Storm Flow
Storm flow	307	180	635	100
Storm sewage at 5-fold dilution	139	110	256	17.4
Storm water with 10-fold dilution	97	67	29.5	5.3
Overflow from storm tanks	47	36	24	5.1

Through these relatively small capacity storm tanks, it is therefore possible to restrict storm water, to a 5.1 per cent discharge, as against 17.4 per cent of the total annual storm flow, at 5-fold dilution. For the remainder of the time, all of the storm sewage flows from the storm tanks, into the treatment plant.

At sewage works where storm water overflows operate, not at 5-fold, but at from 2 to 3-fold dilution (the latter, moreover in the majority), the effect of the storm tanks is still more important and significant.

Storm tanks constructed according to Mannes' design, are relatively inexpensive, if gravity operation is possible, so that after the rain is over, the sewage and sludge may enter the treatment plant. Construction costs, moreover, are not particularly large, especially if the tanks can be erected, thereby involving comparatively little excavation.

The Iserlon plant, in the Ruhr district, consists of storm tanks and Imhoff tanks and is representative of storm tank construction under very favorable conditions. The total head available, for the entire plant, is about 13 ft. There are two storm tanks, designed with hopper bottoms, with slopes of 1:1, leading to a central sludge channel. The tanks are approximately 13.1 x 85.3 x 7.2 ft. effective depth.

The rate of flow from the storm tanks is controlled by an automatic regulating valve. If the storm water exceeds the capacity of the Imhoff tanks, the sewage heads up in the storm tanks. If the rain still continues, the settled sewage begins to flow over the storm tank weirs. If the flow decreases, the contents of the storm tanks, including the sludge, gradually flow into or are flushed into the Imhoff tanks. The storm tank is therefore alternately a retention basin and a settling basin.

Where insufficient head is available, according to English practice, storm tanks must be emptied by pumping. Very high costs and operating difficulties are thus involved and under these conditions, it may be simpler to enlarge the ordinary settling tanks, to permit handling a larger proportion of the storm flow.

Storm tanks, with equipment for pumping sludge, may however, be used to great advantage to prevent clogging of long trunk sewers, or drainage ditches. In the Ruhr Valley, storm overflows are not permissible, because of the use of the river as a source of water supply. The Ruhr Commission in 1912, provided standby storm tanks for this territory. To protect local water supplies, it was necessary to construct a sewer to the Rhine, nearly 4½ miles away. The use of storm tanks, made it possible to design this sewer on the basis of the dry weather flow only, thus relieving it of the entire storm flow, which is perhaps 10 times the ordinary dry weather flow.

Canadian Storm Tanks

Storm sewage is treated at at least two Canadian plants, namely at York Township, Ontario, a plant which has been in operation since 1925, and at North Toronto, Ontario.

York Township.—The York Township plant serves 3 drainage districts, with a total area of 2,500 acres and a tributary population of 40,000. The sewerage system comprises some 14 miles of sewers, larger than 24 in., nearly all of which are combined. Storm tanks are provided to prevent the silting of a rather small receiving stream.

Storm sewage is treated in two hopper tanks, 77 ft. sq. in plan and equipped with Dorr Company mechanism, which forces the sludge to the center of each tank, whence it is pumped to sludge beds.

Operating data in two descriptive articles in the *Canadian Engineer*[4,5], give instructive information as to what storm tanks may be expected to accomplish. At York Township, it was originally intended to pump the material accumulating during storms, as rapidly as formed and a double suction diaphragm pump was installed for this purpose. This type of pump was not found practical and a centrifugal pump is now used.

As a result of tests during the first nine months' operation, storm tank accumulations are classified as follows:

Class I—Coarse sand, stones, cinders and brick fragments.

When dewatered, this material can be handled with shovels. It settles in 30 seconds and comprises 10 per cent of the total accumulation.

Class II—Sand and mud plus organic matter.

Deposits of this kind can be handled only with a tight bucket or pump. But 20 minutes retention is required for precipitation.

In view of these experiences, the original design was modified by providing an additional grit chamber, 77 ft. 0 in. x 6 ft. 6 in. x 5 ft. 6 in. deep, ahead of the storm tanks. This chamber intercepts practically all of the Class I material. As the result of this change, pumping difficulties are no longer experienced.

As soon as a storm commences, the Dorr equipment motor is started and sludge pumping begins. A storm lasting 2.5 hours with a rainfall intensity of 0.2 in. in 5 minutes, caused the deposition of 175 cu. yd. in the storm tanks and 10 cu. yd. in the grit chamber. To handle the deposit in the storm tanks, the mechanism was elevated 8 in. and after the storm was over, gradually lowered every 3 hours. It is concluded that the success of continuous sludge removal from storm tanks of this type depends upon pumping capacity, which must be at least equal to the maximum rate of sludge accumulation.

C. Chamberlain, superintendent of the plant, after more than 2 years' operation, is of the opinion that a centrifugal pump of 1,000 gal. capacity, can, under York Township conditions, handle all of the Class II material, from a storm up to 400 cfs.

North Toronto.—Sewage works at North Toronto, designed by Gore, Nasmith & Storrie, of Toronto, and Harrison P. Eddy of Boston[6], went into operation in the fore part of this year. This plant handles combined sewage from North Toronto, which has at the present time a population of 25,000. The plant is designed for 50,000 population and is served by combined sewers, which carry sewage, brook water and storm water. The plant comprises:

1. Preliminary sedimentation tanks for the removal of coarser suspended matters.
2. Aeration tanks—activated sludge.
3. Covered sludge beds with provisions for artificial heating.
4. Standby tanks for storm flow sedimentation.

The receiving stream at North Toronto is the Don River, which has a drainage area of 180 square miles. Storm tanks were provided by the engineers, because of small summer flow and existing pollution in the Don River, the desirability of preventing objectionable deposits and the avoidance of additional pollution of Lake Ontario.

At North Toronto, all of the sewage, to and including 2 d.w.f., is treated in the plant proper. The excess flow over 2 d.w.f. up to 36 d.w.f., is handled by 4 standby storm tanks, 15 ft. deep, designed on the basis of 30 minutes detention at 6 d.w.f., or 5 minutes at 36 d.w.f.

The English Ministry of Health, requires full treatment for 3 d.w.f. Since the English per capita water consumption is three times that of North Toronto (practically similar to conditions in the United States), it follows that complete treatment under Toronto conditions of 2 d.w.f., is equivalent to twice the maximum quantity required to receive full treatment in England.

For North Toronto, a sewage flow greater than 10 m.g.d. (2 d.w.f.) and up to 36 d.w.f., passes through standby storm tanks Obviously, the North Toronto storm tanks are designed to handle 50 per cent more storm water than corresponds to current English practice.

The design of the North Toronto plant as relates to the degree of treatment of the sewage, is clear from the following data:

Treatment of Different Rates of Sewage and Storm Water Flow

Flow	Complete Treatment	Settled in Storm Tanks 30 Min.	5 Min.	Treated Total	By-passed
5*	5	0	0	5	0
10	10	0	0	10	0
40	10	30	0	40	0
190†	10	0	180	190	0
770	10	0	180	190	580

*D.w.f. †Max. capacity of trunk sewer.

Conclusions

As yet no operating data have been published regarding the storm standby tanks at North Toronto. In fact, but little operating information is available, to guide the designer. Such data are of marked value and doubtless this information will shortly be made available from experiences at North Toronto, supplementing the interesting data of Imhoff and Chamberlain, already mentioned.

With the increasing demand for the protection of inland waters, it is believed that there are many cases where storm water treatment should receive consideration, as evidenced by the installation under construction at Columbus, O., in conjunction with improved sewage treatment works, at present under design. It seems reasonable to conclude that storm standby tanks which have been in use for combined systems for so many years in England and in Germany, will also be more frequently considered in this country where sewage from combined sewers, requires treatment because of the limited flow in the receiving stream.

Bibliography

[1]Disposal of Sewage—T. H. P. Veal, London, 1927.
[2]Sewage Disposal Works—Hugh P. Raikes, London, 1908.
[3]Engberding: Uber die Wirkung von Regenauslaessen und Regenwasserbecken in Staedtischen Kanalisationen, Techn. Gemeindeblatt vom 20, Janaur und 5, Februar 1915.
[4]Canadian Engineer—E. M. Proctor, January 26, 1926, Description of York Township Sewage Works.
[5]Canadian Engineer—C. Chamberlain, Superintendent, York Township Disposal Plant, January 3, 1928, Design and Operation of Storm Tanks.
[6]Canadian Engineer—George C. Nasmith, July 27 and August 3, 1926, North Toronto Sewage Disposal Report.

Taste Elimination with Powdered Activated Carbon

Experiments and Results Obtained at Hamburg, N. Y.; Special Feeder Developed for the Application of the Activated Carbon

By E. A. STERNS
Superintendent Water Department, Hamburg, N. Y.

THE city of Hamburg, N. Y., secures its water supply from the north branch of the Eighteen Mile Creek which flows through the valley of the Boston Hills. It has a water shed of about 54 square miles consisting of woodlands, farmlands and with no industries.

We have a rapid sand type filter plant equipped with all modern facilities except aeration. The properties of the raw water are extremely variable. The turbidities vary from 10 parts per million to 5,000 parts per million. Alkalinity varies from 20 parts per million to 120 parts per million; hardness from 85 parts per million to 125 parts per million. The performance of our plant has been most satisfactory. We have no difficulty in obtaining a pure, clear water at all times, but like all open water supplies we have been troubled with periodic tastes and odors.

The Taste Problem.—Experiments in our laboratory showed distinctly that these tastes and odors in our water are due to the seasonal flow of various kinds of micro-organisms which are being exterminated by the chlorine gas that we are using for sterilization. The chlorine gas combining with the substances given off by these micro-organisms imparts to the water tastes and odors varying with the organisms present.

In the early spring we get the musty taste due to the flow of sirogyra and ulotrix; during the summer months we have the fishy taste and find an abundance of asterionella and synedra; during the early fall months we find synura and protococus which presumably cause the intensive medicated taste. Tastes sometimes occur during the winter months, usually following a thaw.

We were prompted by the complaints of our consumers to make a special effort to remedy this trouble.

We investigated various methods of taste elimination that were being used in other water plants whose problems were similar to ours. Super-chlorination and dechlorination, permanganization, preamoniation were thoroughly investigated. A number of plants using these methods were personally visited. These data in conjunction with available published data were made use of. None of these methods seemed to entirely meet our requirements and solve our problem.

At this time John R. Baylis, of Chicago, published an extensive and important treatise on his experiments with activated carbon filter units. The idea interested us and led to our investigating activated carbon in a powdered form.

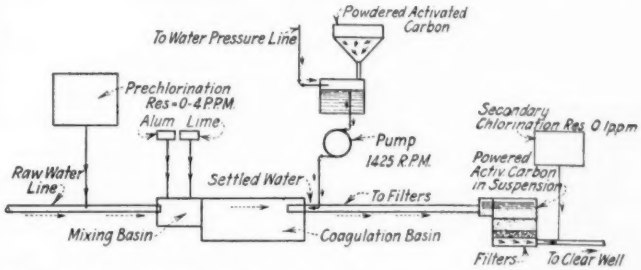
Miniature rapid sand filters were set up in our laboratory. Water samples with tastes of various intensities were prepared and filtered through these experimental filters with the powdered activated carbon introduced in various ways.

Conclusions Regarding Powdered Activated Carbon.—After several methods of applying the powdered activated carbon were used the following conclusions were established:

1. That the absorbing properties of powdered activated carbon are practically unlimited.

2. That to obtain the most effective absorption, provisions must be made for a maximum contact between the powdered activated carbon and the water.

3. That the use of powdered activated carbon would be very economical since our experiments showed that from 0.05 to 0.15 grains per gallon if efficiently applied will suffice to remove all objectionable tastes and odors.



Flow Sheet Showing Point of Application of Powdered Activated Carbon at Filter Plant, Hamburg, N. Y.

With these data on hand we proceeded to find a method by which we could most effectively introduce the powdered activated carbon into our operation.

Application of the Powdered Activated Carbon.—Just at that time one of our dry feeders was available and we decided to try introducing the powdered activated carbon into the mixing basin the same as the coagulants. The results were disappointing yet interesting. The powdered activated carbon was introduced at a rate of 0.15 to 0.5 parts per million with the following results:

1. Most of the carbon, in spite of the rotary agitation in the mixing basin, was floating on the surface of the filters.

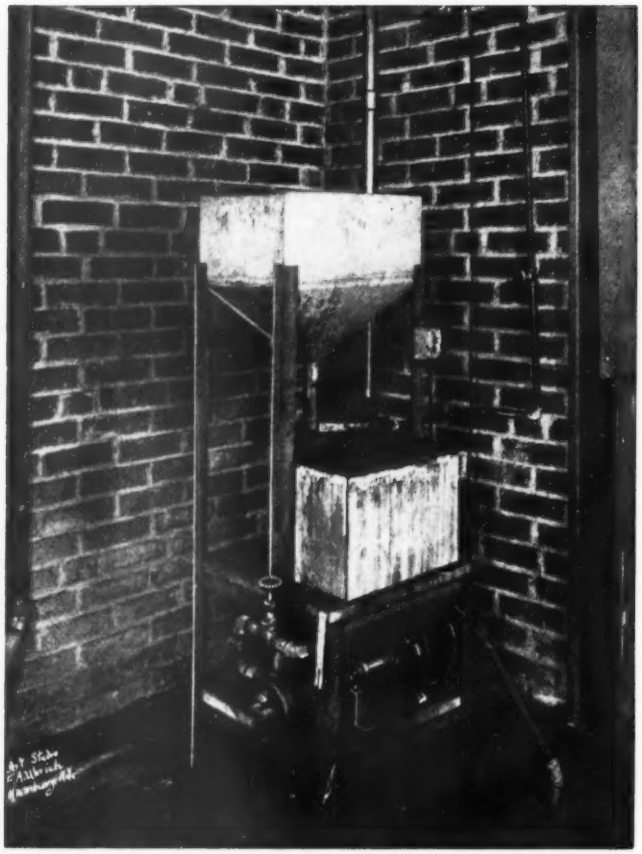
2. The remainder of the carbon in suspension became coated with the floc, making it inactive as an absorbent and consequently settling it out in the coagulation basin.

3. That the method was neither economical nor effective in the elimination of tastes and odors.

The powdered activated carbon was then applied directly on the filters at the rate of 1/8 lb. per hour, or an equivalent 0.085 grains per gallon. The prescribed amount of powdered activated carbon was thoroughly mixed in a pail with about 2 gal. of water. This mixture was then poured into the settled water inlet pit adjacent to the filters, from there it was carried into the filters by the flow of the settled water. This method gave the following results:

1. An objectionable musty taste which prevailed at that time, and which was apparently due to a heavy flow of spirogyra algae, was entirely removed.

2. The carbon being introduced in bulk did not stay long in suspension but rapidly settled, thus sealing the



Arrangement for Application of Powdered Activated Carbon

filter beds in large spots and causing a rapid rise in the loss of head and shortening the filter runs from 30 hours to about 3 hours.

This showed us that the powdered activated carbon must be introduced uniformly at a definite amount per gallon, and that provisions must be made to maintain the powdered activated carbon in continual suspension thereby obtaining not only a maximum contact between the powdered activated carbon and the water but eliminating the rapid settling out of the carbon to the surface of the filters and consequently lengthen the filter runs.

The Feeder.—With these facts in mind we developed a feeder to suit the purpose, as shown on accompanying illustration.

The activated carbon is placed in the hopper in the neck of which are two screw type conveyors on a vertical shaft; the top screw feeding the carbon upwards while the lower screw is feeding downwards. This is to prevent arching in the neck of the hopper for powdered activated carbon arches very readily; from the hopper the carbon is uniformly introduced into the tank, the sides of which are equipped with a perforated small pipe connected to the water pressure line. Within the tank there is a ¾ in. diameter vertical pipe into which the current carries the powdered activated carbon to a small pump running at 1,425 revolutions per minute. The purpose of the pump is two-fold:

1. It churns up the powdered activated carbon placing it in colloidal suspension in the water.
2. It helps to introduce the colloidal mixture into the settled water line under pressure and by means of a spray nozzle meets the current of the influent to the filters as shown in the accompanying flow chart.

This method of application is very simple and most effective in obtaining a maximum contact between the carbon and the influent

We have been using this method, of applying powdered activated carbon for the removal of all periodic tastes, in our water for over a year and have been highly gratified with the results as we are now obtaining at all times a pure sparkling water devoid of all tastes and odors.

Method of Operation.—Our method of operation consists of prechlorinating the raw water to a residual of 0.4 parts per million and maintaining a constant residual of 0.1 parts per million on our secondary chlorination. This we believe is desirable because of the fact that all microorganisms susceptible to chlorine become exterminated before the water comes in contact with the powdered activated carbon.

With this method the settling of the carbon on the filter sand is very gradual and uniform and has little or no effect on the normal loss of head.

We have very good filter runs and find no effect of the carbon backwashing. The carbon merely washes out into the wash trough same as the floc mat.

We have made frequent microscopical examinations of the filter sand and found it to be clean with no trace of carbon particles.

The use of powdered activated carbon for the elimination of tastes and odors from public water supplies is very economical and this method of application is comparatively simple. We are using from .05 to .075 grains per gallon which we believe will eliminate tastes and odors of any intensity generally encountered in an open water supply.

Originally we had contemplated using powdered activated carbon during the objectionable taste period only. But when the unpleasant taste had abated and the use of powdered activated carbon was discontinued a difference in the taste of the water was readily detected. The powdered activated carbon seems to impart to the water a sweetness or flavor that improves the quality of the water. And since the application of powdered activated carbon is so economical we are applying it continually.

▼

Ground Water Supplies in Desert Regions

Recently the Geological Survey, Department of the Interior, has obtained continuous records of the daily fluctuations of the water levels in nearly 100 wells in the Escalante Valley, Utah, by means of automatic water-stage recorders that were installed over the wells. From these records it was possible to compute the amount of water that is annually withdrawn by the desert vegetation from the great underground reservoir beneath this arid region, and hence to estimate the quantity of water that can safely be recovered annually for irrigation or other uses. It is expected that the methods developed in this investigation can be applied in many other desert regions where it is of great consequence to determine the quantity of water available.

A report on the results of the Escalante Valley investigation has been completed by W. N. White and will eventually be published by the Geological Survey. To make the results immediately available, the report has been released to the public in manuscript form. The complete report can be consulted at the office of the Geological Survey in Washington, D. C., and copies of the text, without the illustrations, can be consulted at the district office of the Geological Survey, Federal Building, Salt Lake City, and at the office of Prof. William Peterson, State geologist, Logan, Utah.

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Physical Chemist, Bureau of Engineering, Chicago, Ill.

Design of Mixing Basins

The various larger rapid sand filtration plants throughout the country have many features such as settling basins, filters, marble operating tables, filter rate controllers, etc., somewhat alike. Practically all the larger plants, and a large percentage of the small plants constructed within the past 20 years have rectangular concrete settling basins and rectangular concrete filters of the gravity type, but when it comes to the mixing basin there are several designs and many plants with no mixing basins. One plant might feed the coagulant into the raw-water conduit some distance from the settling basins, another might feed it into the water only a short distance from the settling basins, and another might feed it into the water just as it enters the settling basins. At other plants there will be found baffled mixing basins in which the water flows in horizontal conduits back and forth around the ends of the baffles. The time required to pass such basins will be found to vary from 2 to 3 minutes in some plants to perhaps over one hour in a few plants.

Other filter plants will be found equipped with vertical baffles in which the water flows over and under the baffles. And again the time required to pass the basins will be found to vary widely. There are plants with mechanical mixers or stirrers, and in these mixing basins the time required for the water to pass also will be found to vary widely. A variety of agitating devices have been tried for such basins. In a few plants the water enters circular basins tangentially and flows spirally to a center outlet. The only force given the water is the entrance velocity. Here and there will be found mixing basins of unique design that represent the idea of some individual, and is not copied to any material extent by others.

Mixing Basins in Some of the Larger Plants.—Table I is list of some of the larger rapid sand filtration plants, giving the type of mixing basin, and so far as possible the time of mixing and velocity of the water. Most of the data are taken from published literature on the plants, personal observations, and responses to requests for information on the plants. In a few instances the data are taken from a tabulation on rapid sand filter plants compiled by E. A. Hardin of the Detroit Water Department.

All Mixing Basins Seek to Accomplish the Same Thing.—All the various designs in mixing basins are seeking to accomplish the same thing; that is, to mix the chemicals with the water quickly, and then bring about a flocculation of the coagulation. The fundamental requirement where there is a mixing basin, or conduit used instead of a mixing basin, is to keep the water in a certain state of motion over a certain period of time before it enters the settling basins; not necessarily a uniform state of motion, for a large volume of water in which all portions of the water are flowing along together does not bring about the quickest formation of the flocculation. It is real mixing that is needed, and not only a mixing of the chemicals with the water but a continued mixing of the water. The word "mixing" more appropriately defines the function of the basin than such words as "reaction chamber" or "coagulating chamber."

What the Mixing Basin Should Accomplish.—It is believed with a clear idea of what the mixing basin is supposed to accomplish a basin can be designed more intelligently. First, there is the mixing of the chemicals with the water. This may be done as violently as one may wish so as to bring about a uniform mixing within a few seconds, or a period of about one minute may be used without having to add an appreciable amount more of the chemicals than is required for a more rapid mixing. With any period of time up to about 1 minute there is not much preference of one method over the other even though some claim considerable for a very rapid initial mixing. As the time required for getting the chemicals uniformly mixed increases over about 1 minute increased quantities of chemicals for producing the desired flocculation may have to be added. It may be worth the expenditure of a small amount of energy to bring about a fairly rapid initial mixing, but devices that cause a loss of head of 1 ft. or more probably are not justified.

In the June, 1930, issue of WATER WORKS AND SEWERAGE, it was shown that the first flocculation of the coagulant was accomplished within 1 to 5 minutes after the addition of the coagulant to the water. These particles are so small they are not visible without magnification. Up to this point the agitation may be fairly violent. But these small particles must unite into larger particles. There might be from 500 to 5,000 such coagulated particles per cubic centimeter of water. The problem is to produce a motion of the water that will bring these particles together in the quickest time so that there will be only about 5 to 10 larger particles per cubic centimeter. Now one would not take a beaker filled with water and go walking around in the room with it to bring about the flocculation in preference to stirring, yet the walking may produce agitation greatly in excess of what the water would receive in a settling basin. The fact that the water is in motion does not mean that it is mixing rapidly.

The minute particles of coagulated matter must strike other particles in order that they may become united. If every particle was traveling in an opposite direction from that of the surrounding particles they probably would strike in the quickest time. We realize that it is not possible to produce such an ideal condition, so the next best thing is to have small volumes of water

traveling in various directions. Several hundred small particles have to be united into one large particle. The smallest particles first unite into masses of two particles. These united particles must then unite with other masses of two particles to form groups of four of the original small particles. The groups of four unite into groups of eight particles, the groups of eight into groups of sixteen, then to groups of thirty-two, sixty-four, one hundred and twenty-eight, etc. It, of course, is evident that the grouping does not take place in this geometrical ratio, for a group of ten of the small particles at one moment might unite with one independent small particle and the next moment with a group of five, and so on until they are all united into large flocculated particles composed of hundreds of the small coagulated particles which were first formed immediately after the addition of the coagulant.

Table I—Mixing Basins in a Few of the Larger Filtration Plants

	Capacity of Plant M.G.D.	Year Operation Started	Type of Mixing Basin	Time of Mixing Minutes	Velocity of per Second Flow, Feet
Akron, O.	50	1915–19–27	Horizontal baffles	1	
Atlanta, Ga.	30	1923	Horizontal baffles	40	.5
Baltimore, Md. (old)	128	1915	Horizontal baffles	30	1.4
Baltimore, Md. (new)	112	1928	Horizontal baffles	40	
Buffalo, N. Y.	160	1926	No mixing basin	1	
Cambridge, Mass.	14	1923	No mixing basin	1	
Cincinnati, O.	112	1907	No mixing basin	3	
Cleveland, O. Division Ave.	150	1918	Vertical baffles	36	.4
Baldwin	165	1924	Hydraulic pump	1	
Columbus, O.	54	1908-23	Mechanical mixers / Vertical baffles	60	
Dallas, Tex. (2nd pl.)	15	1923	Horizontal conduits		
Denver, Colo.	64	1924	Horizontal baffles	20	
Detroit, Mich.	320	1923	Horizontal baffles	3	1.3
East St. Louis, Ill.	27		No mixing basin		
Erie, Pa.	32	1914–25	Vertical baffles	2	
Flint, Mich.	28	1912–18–24	Vertical baffles	30	.6
Grand Rapids, Mich.	30	1912–24	Horizontal baffles	45	1.0
Harrisburg, Pa.	22	1905–23	No mixing basin		
Fort Worth, Texas	20	1912–18–23	Horizontal baffles	40	.5
Kansas City, Kans.	25	1909–12–27	Horizontal baffles	5	1.1
Kansas City, Mo.	96		Spiral inward flow		
Knoxville, Tenn.	15	1928	Mechanical mixing	20	
Louisville, Ky.	126	1905–14–28	No mixing basin		
Miami, Fla.	10	1926	Mechanical mixing	30	
Minneapolis, Minn. (1)	78	1913	Horizontal baffles	15	
(2)	40	1927–30		3	
New Orleans, La.	112	1909–28	Horizontal conduits	60	
Norfolk, Va. (1)	16	1899	No mixing basin		
(2)	12	1922	Horizontal baffles	7	.8
Oakland, Cal.	12	1927	Mechanical mixing	25	
Oklahoma City, Okla.	16	1906-23	Vertical baffles / Mechanical mixing	30	
Passaic Dist. Little Falls, N. J.	42	1902–19	No mixing basin		
Philadelphia, Pa.	60	1922–26	No mixing basin		
Providence, R. I.	48	1926	Spiral		
Richmond, Va.	30	1924	Horizontal baffles	10	.75
Sacramento, Cal.	32	1924	Mechanical mixing	45	
St. Louis, Mo. Chain of Rocks	160	1915	Horizontal conduits	25	1.6
Howard Bend	80	1930	Spiral inward flow	20	
St. Paul, Minn.	42	1921–26	Vertical baffles	7	
Trenton, N. J.	30	1914	No mixing basin		
Toledo, O.	34	1910–21–23	Horizontal baffles	50	.45
Tulsa, Okla.	24	1928	Spiral inward flow	22	
Washington, D. C.	80	1927	Horizontal baffles	27	1.0
Winston-Salem, N. C.	16	1926	Mechanical mixing		
Wilmington, Del.	12	1917–26	Horizontal baffles	7	.4

This is the real function of the mixing basin after the chemicals have been uniformly distributed throughout the water, and is why it is desirable to have a prolonged mixing period. If the chemicals are merely mixed with the water and it is then turned into the settling basins before the flocculation has formed, the water is not entirely still and while the flocculation will eventually take place it certainly is not the ideal condition to hasten the flocculation. As time of mixing was discussed in the August, 1930, issue of WATER WORKS AND SEWERAGE, the present article will be limited largely to the types of mixing basins now in general use.

Mixing Basins Not Included in Many of the Earlier Plants.—The value of prolonged mixing apparently was not known to the earlier designers of rapid sand filtration plants. In fact most of the earlier plants were constructed by filter companies in accordance with the design they had to offer. It was not until after the year 1900 that engineers began to make their own designs. In a list of 154 rapid sand filtration plants given by Hazen,[1] which included plants constructed prior to 1900, all of the filters with the exception of two were manufactured by some filter company, and it is assumed that they largely followed their own ideas of what was most suited for the particular water. If a consulting engineer was employed, it was somewhat like buying a pump, or an engine. The engineer made specifications so that the filter companies could bid on their own products. Of these 154 plants it is doubtful if any of them had a real mixing basin, unless some of them were softening plants. The number having mixing more than a flow of a short distance in the raw water lines very likely were few. Hazen makes no mention

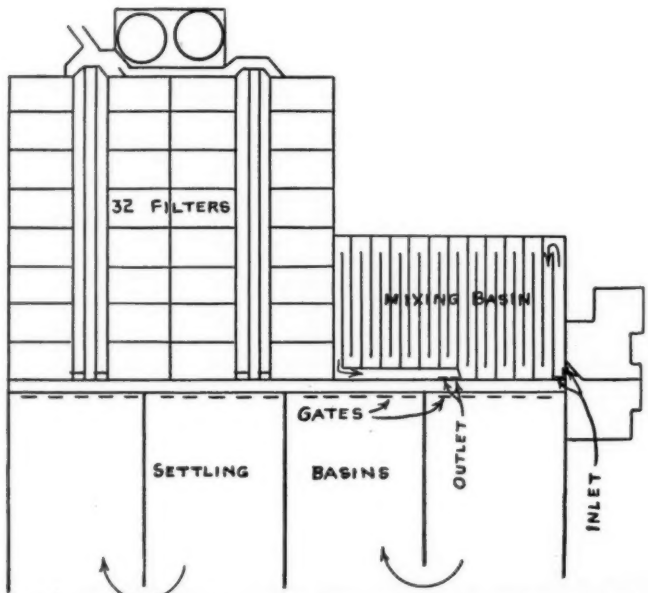


Fig. 1—General Layout of Old Filtration Plant, Baltimore, Md

of mixing basins in the third edition of his book. Fuller apparently conducted all his experiments at Louisville without considering mixing basins. At least there is no reference to mixing basins in his report.[3] Stein, in the

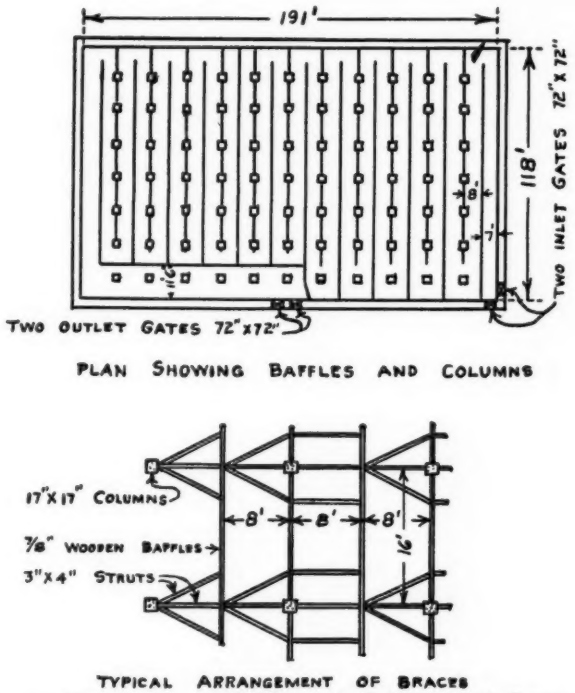


Fig. 2—Arrangement of Baffles and Columns and Braces at Mixing Basin, Baltimore

first edition of his book published in 1915,[3] makes the following statement in regard to the introduction of chemicals into the water:

"The chemicals should be thoroughly mixed with the raw water, but violent agitation in mixing is to be avoided, as tending to break up the flakes of coagulum. Sufficient mixing is generally provided, where the chemicals enter the raw-water main 100 ft. or more from the sedimentation basin, by the agitation of the flow through the pipes. At some plants especially baffled mixing chambers are provided in connection with sedimention basins."

The above references are given to show that rapid sand filtration started without the use of mixing basins, and that as late as 1915, after several hundred filtration plants had been constructed, designing engineers in most instances were not convinced of the advantage of mixing basins for all plants. In fact most of the plants designed up to that time which had mixing basins were designed for some coagulant other than aluminum sulphate. The iron and lime treatment required prolonged mixing to produce satisfactory clarification of the water. It has been since 1915 that most of the filtration designing engineers have become convinced of the necessity of mixing basins, if the best results are to be obtained with aluminum sulphate. In fact we see the 160-M.G.D. plant at Buffalo, N. Y., which was completed in 1926, with no mixing basin and only a short time in the raw water conduit after the addition of the coagulant.

Now, not only are most designing engineers providing mixing basins, but they are gradually increasing the time of mixing. Very few recent designs for moderate size or large size plants provide for less than 20 minutes mixing time. It is believed that this gradual lengthening of the mixing time has been brought about by tests conducted on existing basins which have shown better settling by using the full time provided for in the basins than only a part of the time. Hopkins[4] collected samples of water at various points as the water passed through the Baltimore mixing basin and found that the time required to settle to a given turbidity decreases up to the end of the mixing basin, which is about 30 minutes mixing time at rated capacity of the plant. Also laboratory stirring machines have come into use in some of the better equipped water works laboratories, and the value of prolonged mixing on the settling time has been amply demonstrated.

There is another factor that probably helped retard the introduction of mixing basins. Many of the earlier filtration engineers and chemists who were designing or operating filtration plants had the idea that the water must have a certain amount of the flocculated matter present in the water going to the filters for the filter beds to function properly. It has been demonstrated very conclusively that as much of the coagulated matter as is practical should be removed from the water, and naturally we might expect more consideration to be given the mixing basin in recent designs.

Proportion of Filtration Plants Having Mixing Basins.—The writer does not have exact information as to the proportion of filtration plants that have mixing basins. Data are being collected, but with the large number of plants in the United States this is quite a task. Not only this, but it is impossible to get replies from many plants. For two states where the data furnished by the departments of health included mixing basins in their statistics, there were 56 plants out of a total of 125 that had mixing basins. This is only about 45 per cent of the total number of plants. Incomplete returns from other states indicate the percentage to be about 60 to 70 per cent for the entire country. It is not wise to base too much upon incomplete statistics. The data includes plants of all kinds that supply at least a portion of the water for drinking purposes. If it applied to the quantity of water filtered by rapid sand filters it is believed that the percentage of water filtered in plants having mixing basins would be very much higher. Probably as high as 75 per cent, for a larger percentage of the larger plants have mixing basins.

Types of Mixing Basins.—There are several types of mixing basins or mixing devices in common use, besides a few basins of unusual design. Chief consideration will be given the types used most extensively, or those that give the promise of being used extensively in the future. The basins may be classified as follows:

1. Chemicals applied to raw water pipes or conduits.

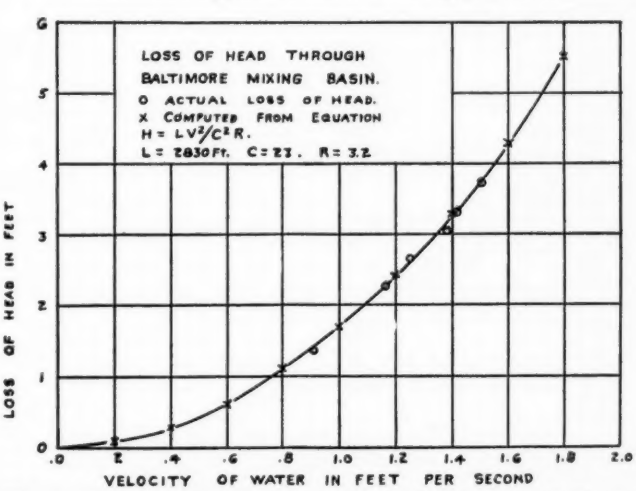


Fig. 3—Curve Showing Loss of Head Through Baltimore Mixing Basin

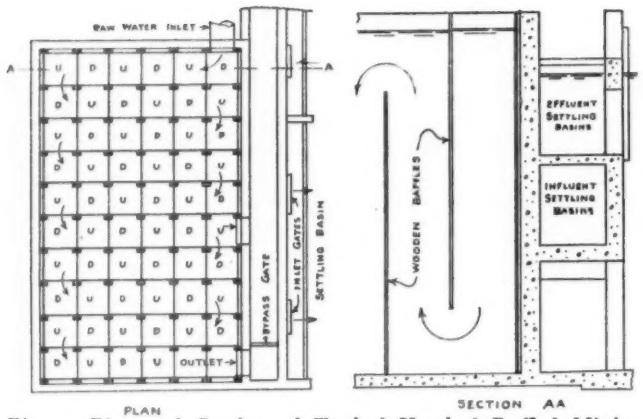


Fig. 4—Plan and Section of Typical Vertical Baffled Mixing Basin

2. Horizontal baffled basins (around the end).
3. Vertical baffled basins (over and under).
4. Mechanical mixing.
5. Spiral inward flow.
6. Other types, such as the hydraulic jump, air agitation, etc.

Chemicals Applied to the Raw Water Line

All Plants Recognized the Importance of Having the Chemicals Uniformly Distributed.—It was realized from the very beginning of rapid sand filtration that the chemicals should be uniformly distributed throughout the water. For the earlier plants, it was thought that so long as there was sufficient time for the uniform distribution of the chemicals this was all that was necessary. This is why we see the chemicals added to the raw water line only a short distance from the settling basins in so many plants. This was almost the universal custom for water coagulated with aluminum sulphate up to about 1910, when engineers began to design most of the larger plants. Sometimes the coagulant was added to the water before it passed the low-lift pumps, which probably gave a very rapid initial mixing. The greatest trouble with the use of raw water lines for mixing basins is that such a long line has to be used before good flocculation is brought about, necessitating the addition of the coagulant some distance from the settling basins. The first idea was merely to get the chemicals evenly distributed throughout the water and to depend upon the flocculating to take place in the settling basins.

Flocculation Can Be Produced in Conduits.—There is no doubt about being able to produce flocculation in conduits with a straight line flow. Higher velocities should be maintained in such lines than in baffled basins if it can be directed into the settling basins or around any turns without breaking up the flocculation. It is believed that a velocity fully twice as great as that of the baffled basins may be used where there are no abrupt turns in the conduit. It is not believed that the use of pipe lines or conduits for mixing basins is the most desirable procedure under most conditions. It is believed that a longer time is required to bring about good flocculation than in basins especially designed for agitating the water. The baffled basin builds up a higher loss of head than the straight conduit for a given mixing time, but even after taking this into consideration it is believed the baffled basin is to be preferred to straight conduits.

Some difficulties may be encountered in the use of pipe lines or other closed conduits for mixing basins. Deposits from the chemicals may accumulate, especially where lime is added to the water, and such deposits may not be easy to remove. Also where chemicals have to be fed into lines under pressure there is frequently trouble from the chemical feeding lines becoming air-bound. Probably the chief reason why long periods of mixing in conduits are not practical is the necessity of having the chemical application such a long distance from the balance of the plant. Long chemical lines usually give trouble, and to have a chemical house some distance from the filters is not desirable. It should be evident that under most conditions the construction of a long line merely to coagulate the water is not as economical as the usual type of baffled basin or mechanical mixing basin. It is only where the line is necessary for transporting the water and it is convenient to have the chemicals applied at some distance from the filters that such a procedure can be considered the most economical. The mixing basin in the Chain of Rocks Plant at St. Louis, Mo., may be considered a conduit basin.[5] It is

Table II—Computed and Measured Loss of Head Through Baltimore Mixing Basin

	78 M.G.D. Velocity in Feet Per Sec.	Loss of Head in Feet	100 M.G.D. Velocity in Feet Per Sec.	Loss of Head in Feet	112 M.G.D. Velocity in Feet Per Sec.	Loss of Head in Feet	120 M.G.D. Velocity in Feet Per Sec.	Loss of Head in Feet	132 M.G.D. Velocity in Feet Per Sec.	Loss of Head in Feet	140 M.G.D. Velocity in Feet Per Sec.	Loss of Head in Feet	Formula
Entrance to mixing basin, two gates 72"x72"	2.10	0.068	2.69	0.112	3.01	0.141	3.22	0.161	3.55	0.196	3.76	0.219	$Q = .8A\sqrt{2gh}$
Friction through basin	0.91	0.036	1.17	0.059	1.25	0.068	1.38	0.011	1.43	0.011	1.50	0.013	$H = LV^2/C^2R$
Enlargement 18 times at end of baffles	0.91	0.005	1.17	0.007	1.25	0.008	1.38	0.011	1.43	0.011	1.50	0.013	$H = (V - V_1)^2/2g$
Contraction 17 times at end of baffles	1.05	0.024	1.34	0.039	1.43	0.044	1.58	0.053	1.63	0.060	1.72	0.066	$H = \left(\frac{1}{C} - 1\right)^2 \frac{V^2}{2g}$
Enlargement 6 times at end of baffles	0.64	0.005	0.92	0.006	0.99	0.006	1.09	0.007	1.13	0.008	1.19	0.009	$H = (V - V_1)^2/2g$
Contraction 5 times at end of baffles	0.91	0.013	1.17	0.016	1.25	0.018	1.38	0.022	1.43	0.024	1.50	0.026	$H = \left(\frac{1}{C} - 1\right)^2 \frac{V^2}{2g}$
Column losses, 132 times	0.91	0.086	1.17	0.140	1.25	0.174	1.38	0.202	1.43	0.224	1.50	0.236	$H = F\ (V^2 \div 2g)$
Column losses, 6 times	0.64	0.005	0.82	0.008	0.99	0.012	1.09	0.014	1.13	0.015	1.19	0.017	$H = F\ (V^2 \div 2g)$
Baffle struts, 480 sets	0.91	0.223	1.17	0.370	1.25	0.408	1.38	0.440	1.43	0.502	1.50	0.555	$H = F\ (V^2 \div 2g)$
Losses at five 180 degree bends	0.77	0.138	1.04	0.249	1.12	0.286	1.24	0.352	1.28	0.376	1.35	0.416	$H = C\ (V^2 \div 2g)$
Losses at eighteen 180 degree bends	0.98	0.804	1.125	1.290	1.34	1.485	1.48	1.810	1.53	1.934	1.61	2.144	$H = C\ (V^2 \div 2g)$
Total computed loss		1.407		2.296		2.650		3.155		3.439		3.799	
Actual measured loss		1.360		2.28		2.680		3.07		3.37		3.71	

PUBLIC LIBRARY
DETROIT MICH.

composed of a reinforced concrete box 2,382 ft. long, which is divided into four conduits. The four compartments may be used in series or in parallel. Under normal conditions the water travels the full length four times, or a distance of 9,528 ft., at an average velocity of 3.3 ft. per second at 150 M.G.D.

Horizontal Baffled Mixing Basin

Construction of Horizontal Basins.—The most common type of mixing basin is the horizontal baffled basin in which the water travels back and forth around the ends of the baffles. The outside walls of the basins are usually constructed of reinforced concrete, and the baffles are usually thin partition walls, frequently thin wooden boards which require supports and bracing. The supports and bracing add turbulence to the water. Figures 1 and 2 show sketches of the mixing basin in the old plant at Baltimore, Md. This is a typical horizontal baffled basin. The thin partition walls are designed to withstand only a small head of water. Some care has to be exercised in the filling of the basin, but once filled there is only a slight pressure on the baffles.

There are several ways of constructing the baffles. Sometimes the walls are made so smooth the flow, except at the turns, receives little agitation; no more than it would receive in a straight conduit. The prevailing method of construction probably is to have only one thin wooden wall ¾ to 1 in. thick, with all supports and bracing projecting into the water. This makes the cheapest type of construction and, as stated, the supports and bracing serve to produce agitation. Sometimes plastered cement walls reinforced with expanded metal are used, but such construction is more expensive and probably does not give as good agitation as the wooden walls.

Velocity Through Horizontal Basins.—It is not difficult for engineers to design mixing basins that are safe structurally, but it is difficult to decide upon the velocity that will produce the best results. One-half to 1.5 ft. per second is the usual designed velocity for the rated capacity of most plants. With a flow that may vary all the way from one-fourth rated capacity to a maximum in excess of the rated capacity, it is evident that there is considerable fluctuation in the velocity through the mixing basins in some plants. The dependence of the violence of agitation upon the velocity through the basin probably constitutes the most serious objection to baffled basins, or any mixing device that depends upon gravity for the flow. Not only is it difficult to select the most desirable velocity when designing the basin, but the most desirable agitation varies with the water and perhaps with the kind of chemicals used. A velocity of 2.0 ft. per second might not be excessive for highly turbid water in a certain basin, and a velocity of less than 1 ft. per second might allow sediment to accumulate at the bottom of the basin. With fairly clear raw water the maximum velocity probably should not exceed 1 ft. per second. These velocities all refer to the coagulating velocity. It is evident for the first few minutes that the velocity might be much greater without interfering with the final flocculation of the water. Hoover[6] states that a velocity of 0.3 ft. per second through the mixing tanks at Columbus, O., was insufficient for bringing about good flocculation of the water. Certainly such a slow velocity will allow sediment to accumulate in any mixing basin.

In the absence of more specific data, the writer believes that a velocity of about 1.3 ft. per second for rated capacity is approximately the most desirable velocity for highly turbid waters, and that a velocity of about 0.8 ft. per second is the most desirable for low turbidity waters. Where the turbidity fluctuates from low to high, perhaps about halfway between these figures should be selected. Where the water is softened and there is a heavy precipitate it may be essential to use a velocity between 1.5 and 1.8 ft. per second to prevent excessive accumulation of sediment in the basin. There is considerable doubt as to the advisability of using baffled basins for softening plants.

Loss of Head in Horizontal Baffled Basins.—There is not much specific information as to the best means of calculating the loss of head that will take place in a mixing basin. In designing the basin it is best to make liberal allowance for the head being more than is calculated. If the walls and bottom were perfectly smooth and straight, the friction loss could be computed with considerable exactness by use of certain hydraulic formulas. With the number of turns, supports, and bracing timbers varying for different basins the coefficient determined for one basin will not hold for another. The most specific information on the hydraulics of mixing basins has been furnished the writer by Jas. W. Armstrong, of Baltimore. He made very careful measurements of the loss of head for the basin in the old plant, and also computed the losses by well known hydraulic formulas.

The sketches in Figs. 1 and 2 show outline of the Baltimore mixing basin, and Table II shows the computed and measured losses. The number of factors that have to be taken into consideration are enough to discourage most any one in attempting to compute the loss, but Mr. Armstrong shows that it can be done. This excellent hydraulic computation, the most thorough the writer has seen on mixing basins, was made in 1919, to be used as a basis for designing the mixing basin in the new plant at Baltimore. Six different hydraulic formulas were used to calculate the loss through the mixing basin. These formulas also are given in Table II.

The curve in Fig. 3 makes use only of the formula $H = LV^2/C^2R$ for calculating the loss of head in the Baltimore basin in which:

H Loss of head in feet.
L Length in feet.
V Velocity in feet per second.
C Coefficient.
R Hydraulic radius.

The length of water travel in the basin was calcu-

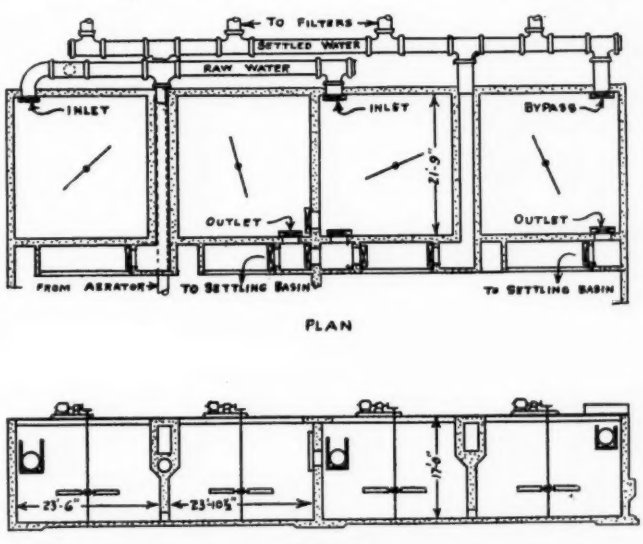


Fig 4—Mixing Basin in Filtration Plant, Highland Park, Ill.

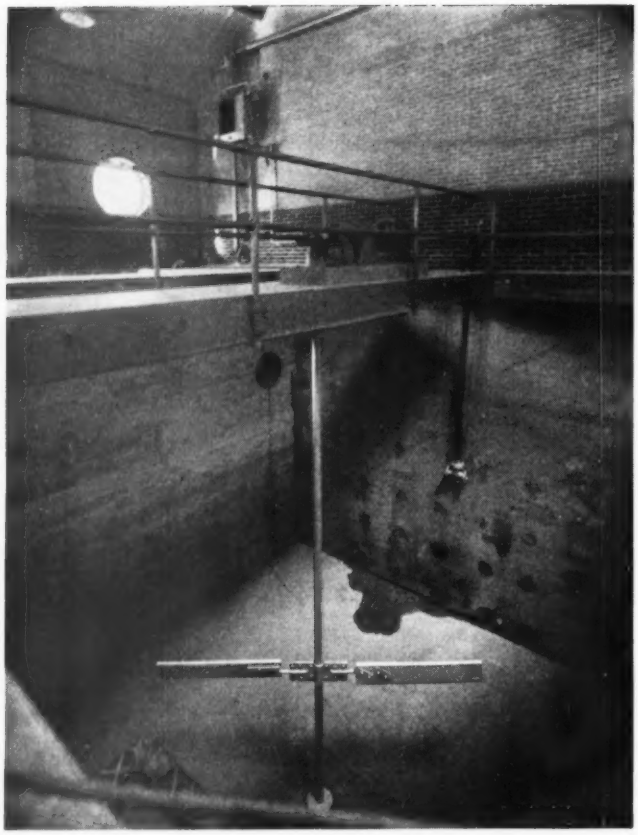


Fig. 6—Mechanical Stirrer for Mixing Basin, Highland Park, Ill.

lated to be 2,830 ft. The actual travel might have been a few feet shorter or longer. The hydraulic radius was calculated to be 3.2, and the actual radius might vary slightly from the figure given. From the loss of head as actually measured at the 100 million gallon rate the coefficient C was found to be 23. Using these values in the above formula a curve is obtained that coincides very closely with the observed results. This indicates that the formula may be used with considerable accuracy for this particular basin. There, of course, is no way of estimating C for a certain basin except by the complicated mathematical computations used by Mr. Armstrong, unless the basin is in operation and the loss of head can be measured for some certain rate. Then the loss for any other velocity may be computed fairly accurately. In fact a more simple procedure gives approximate results. The loss of head varies as the square of the velocity. Loss of head measurements made by Smedberg[7] on the mixing basin at Greensboro, N. C., also shows this method of computation to be approximately correct. In the Baltimore basin it will be noted that the twenty-three 180 degree bends give two-thirds of the total loss, and that the loss figured for straight flow through the entire 2,830 ft. was very small compared with other losses.

Vertical Baffled Mixing Basin

Description of Basin.—There are quite a few vertical baffled mixing basins in use throughout the country, though they probably are not so numerous as the horizontal type. The travel of the water is upward and downward, going over and under every other baffle, instead of traveling in a horizontal direction. The distance between the turns is limited to the depth of the basin. Usually it is not desirable to have the depth more than 25 to 30 ft. on account of the cost of constructing deeper basins. Usually there is no cross bracing, columns, and other supports projecting into the water to help increase the loss of head and add turbulence to the water. The large number of turns for a given distance insures sufficient turbulence in most basins. As the water travels upward and downward there must be a wall on all four sides, and the walls provide all cross bracing that is necessary, unless the opening is unusually large. Usually instead of making the cross section of the conduits very large the flow is divided into two or more streams, though there are not many large plants having vertical baffled basins. Figure 4 shows typical section of a vertical baffled basin.

Plants in Which the Vertical Baffled Basin Is Suitable.—For small plants the vertical baffled mixing basin is a very good type to use, and it probably is just as economical as the horizontal type. It is not so easy to construct a horizontal baffled mixing basin for a long period of mixing with a very small flow of water, unless it is made in a series of horizontal conduits stacked on top of each other. Otherwise it will spread out over considerable area. The prevailing practice for small plants with horizontal baffled basins is to give the water only a very short period of mixing. Now that the tendency is towards a longer mixing time it is likely that the vertical baffled basin, and basins using mechanical agitation will be the types used most extensively in the future for small plants. For plants of 10 to 20 million gallons daily capacity, either vertical or horizontal baffled basins are suitable and probably cost about the same to operate. If the plant is larger than 20 million gallons capacity there is doubt as to the wisdom of using vertical baffled basins. They may be used for most any size plant if the flow is divided, but usually this is not the most desirable procedure.

Loss of Head in Vertical Baffled Mixing Basins.—The loss of head for the vertical baffled basin may be computed in the same general manner as for the horizontal basin. Usually there is no cross bracing, columns, and other supports projecting into the water to help increase friction losses. Calculating the loss is somewhat like calculating the loss in a conduit with numerous 180 degree bends. Nearly all the loss takes place in the bends. If the figure of approximately 0.1 ft. for each 180 degree bend as computed for the Baltimore basin at a velocity of 1.2 ft. per second holds for other basins, it is evident that for long periods of mixing in vertically baffled basins the loss of head will be great. With the distance between turns averaging 25 ft., and a velocity of 1.2 ft. per second, it will require about 85 turns to obtain 30 minutes mixing period. A loss of head of 0.1 ft. per turn would give a total loss of 8.5 ft.,

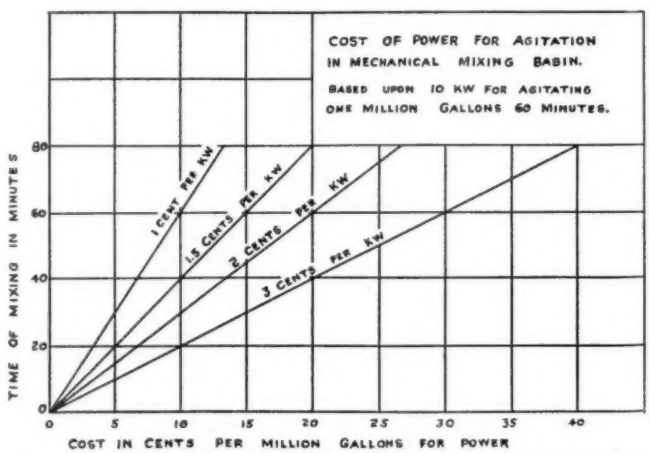


Fig. 7—Cost of Power for Pumping Against Friction Head in Baffled Mixing Basin

which is a figure almost prohibitive and certainly not economical. It is evident there is not a loss of 0.1 ft. per turn for a small volume of flow, but the loss is considerable. It might be said that large size sections for vertical baffled mixing basins are not practical where fairly long periods of mixing are desired, especially if the velocity is in excess of 1.0 ft. per second.

A well known case of error in the design of a vertical baffled mixing basin for a large plant was the original design of the mixing basin for the Division Ave. plant at Cleveland, O. The basin was provided for 0.6 hour mixing time at rated capacity. Ellms[8] states that the original design provided for a velocity of about 60 ft. per minute, and that it was impossible to get the required amount of water through the basin. One hundred and eight of the original 144 baffles were removed, reducing the velocity to about 20 ft. per minute. He also states that this gives a loss of head less than 3 ft. If the velocity was reduced to where it was only one-third of the original, the loss through the basin as first constructed would have been approximately 9 times what it is with the present baffling.

Mechanical Mixing Basins

Extent of the Use of Mechanical Mixers.—Mechanical agitation has been used to a certain extent for some time in softening plants, but it is only recently that this type of mixing has been given much consideration where a coagulant only is applied to the water. The first mechanical mixing basin of which the writer has knowledge was installed at Owensboro, Ky., in 1911[9] unless the Algiers, La., plant was constructed prior to this date. It is believed that most of the softening plants constructed in the future will be provided with mechanical agitation, and that a large percentage of the basins in other plants also will be provided with mechanical agitation. Looking through the water purification literature we find descriptions of 10 or 12 plants using mechanical mixing. The writer has a list of 35 plants using this type of mixing. The list is not complete, and there may be 60 to 75 plants throughout the United States provided with mechanical mixing.

Design of Mechanical Mixing Basins.—It is desirable to have at least two tanks, except possibly in very small plants. There is not much that may be said about the tank itself. It must be safe structurally, and each tank should be designed to be safe with adjoining tanks or reservoirs filled. Steel might be the most economical for small plants, but concrete is the best to use under most conditions. The connections between the tanks and the outlets should be large enough to take the flow with only a slight increase in the velocity of the water over that in the tanks. The tendency has been to provide openings too small. If a velocity of 1.0 ft. per second gives the best coagulating results, the outlets from the tanks should not exceed about 1.5 ft. per second. Some are of the opinion that circular tanks are better than square tanks. Recent experience with square basins demonstrates that this shape is entirely suitable. In fact, such basins may provide even better turbulence of the water than circular basins.

The mixing tanks in the Highland Park, Ill., filtration plant is a good example of modern design in mechanical mixing basins. This plant was designed by Pearse, Greeley & Hansen, and was put in operation during the summer of 1930. Sketches of the basin prepared by the writer from the engineers' plans are shown in Fig. 5. The photograph in Fig. 6 was furnished by George B. Prindle, superintendent of the plant. It shows the agitating device very clearly. The agitators are composed of wooden blades with the tip ends of the blades 61 in. from the center of the shaft. The wooden part of the blades is 47 in. long, 8 in. wide, and 1 in. in thickness. The boards are fastened to metal arms, which are fastened to the vertical shaft. Each agitator is driven by electric motor, reduction gears being provided to reduce the speed. The agitator blades are set with a pitch of 1 to 8 from the vertical, the shaft being rotated in a direction to give the water a slightly downward velocity. When the shaft is rotated at 4 revolutions per minute the velocity at the tip end of the blades is approximately 128 ft. per minute.

It is difficult to determine the velocity of the water in a basin when it is moving in various directions. The best the writer could estimate from floating objects in the Highland Park tanks was a water velocity of about 1.0 ft. per second. If this is correct, the velocity imparted to the water throughout the entire tank was approximately one-half the velocity at the end of the blades. This is about as simple a form of agitation as one may wish.

The entrance and outlet to mechanical tanks should be in the direction of flow, for this helps to set the water in motion. The writer has no specific information, but is of the opinion that it is desirable to use a greater velocity of flow in a circular basin than in a square basin. In square mechanical tanks the water should be in a state of motion about the same as it is in baffled basins; that is, from 0.8 to 1.4 ft. per second when operated at rated capacity. The capacity, of course, has nothing to do with the velocity in mechanical basins. It is believed that in the circular tank the velocity should be about the same as in straight conduits. Perhaps a velocity of 1.5 to 3.0 ft. per second will give the quickest flocculation of the coagulated matter in circular tanks.

The 2-liter beaker and laboratory stirring machine used quite extensively for experimental work may be called a miniature of the large circular tanks. A velocity of 1 ft. per second at the tip of the blades seems to give the best results. This imparts a velocity of about 0.8 to 0.9 ft. per second to the water. It is presumed that this imparted velocity will be about the same for large circular tanks. Cox[10] found by using one-liter samples that a velocity of 0.25 ft. per second was required to keep the floc from settling, and concluded that 15 minutes stirring at 0.5 ft. per second velocity of the water was the most suitable for the particular water with which he was experimenting. He also found that satisfactory flocculation was produced within 20 minutes stirring at 0.25 ft. per second and within 8 minutes at a velocity of 0.8 ft. In large plants it seems to be necessary to have velocities in excess of what seem best in laboratory experiments. A large circular tank for the water with which Cox was experimenting probably should have a velocity of at least 1.5 ft. per second, and a rectangular tank about 0.8 ft. per second. There is no specific proof for this assumption, though it seems to be a fact.

Spiral Inward Flow

Of the types of mixing basins now used to a very limited extent, only the spiral inward flow tank gives the promise of being used to considerably greater extent than it is being employed at the present time. The following description of the spiral inward flow tank is given by Kiersted[11]:

"If water is introduced into a circular basin tangentially at the rim through several openings and taken out through a vertical shaft at the center, it will rotate

and will reach the outlet by inward spiral flow. It is evident that the velocity of rotation must increase as the center of the basin is approached. The hydraulic principle involved is that the velocity of rotation varies inversely as the distance from the center. This principle is the reverse of that of wheel rotation."

It seems that the increase in velocity as the water approaches the center is the opposite of what is best for the flocculation. Hatcher[12] states that for 30 min-

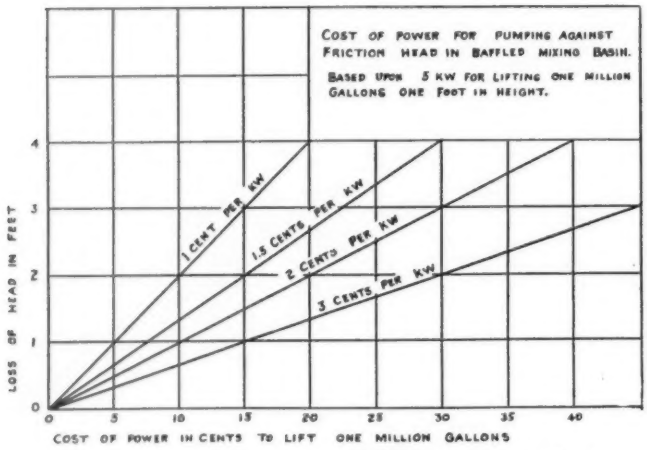


Fig. 8—Cost of Power for Agitation in Mechanical Mixing Basin

utes mixing the loss of head may range from 1 to 4 ft. One to 2 in. should constitute the maximum loss of head in well designed mechanical mixing basins. The spiral inward flow tank avoids the necessity for installing mixing devices, but on the other hand its shape has to be confined to a circle whereas rectangular tanks are the cheapest to construct and require less space. The velocity of spiral inward flow tanks should be about the same as for straight conduits or for circular tanks with mechanical agitation; that is, about 1.5 to 3.0 ft. per second.

Other Types of Mixing Basins

The mixing basins already described constitutes about 98 to 99 per cent of the total number of such basins in the United States. Occasionally we find some unusual type of mixing basin or mixing device. There are several plants using the hydraulic jump, the largest being the Baldwin Ave. plant at Cleveland, O. Ellms[13] gives a very complete description of this type of mixing basin in his book on water purification. The water is spread out to where it is not very deep as it flows down an incline. The momentum gained rebuilds most of the lost head, though there is still considerable loss through the device. This produces considerable turbulence of the water and insures a rapid initial mixing of the chemicals with the water, but at the expense of at least 1 ft. loss of head. This seems like a rather expensive means of getting the chemicals mixed with the water, especially as the mixing is complete within less than 1 minute is most of the usual types of mixing basins. The value of prolonged mixing has been so firmly established it seems that even though a plant installs the hydraulic jump it is just as essential to have a long period of mixing as it would be if the hydraulic jump was not installed.

In a few instances air has been used to aid in mixing and flocculating the coagulant. If applied properly, it will produce very good results, but it has no advantage over the usual types of mixing and is not worthy of serious consideration under most conditions. There may be other types of mixing devices used to a very limited extent of which the writer has no knowledge, but it is unlikely that they will ever be used extensively.

Power Cost for Mixing Basins

Figures 7 and 8 show means of calculating the power cost of mixing basins. The lines in Fig. 7 are based on the amount of power required to lift the water against the head lost in the mixing basin. The power required is assumed to be 5 kilowatt-hours for pumping one million gallons of water against a head of 1 ft. If the pumping equipment is more efficient than this, then the power required is less. It is believed there is more likelihood of it being more than less. Where there is considerable loss of head the power cost becomes an item worth considering.

The lines in Fig. 8 were based on the best information the writer could get on mechanical mixing. There is not much information available at the present time on the power requirement for this type of basin. The power requirement for the agitators in the Highland Park plant given the writer by Mr. Prindle was approximately 8 kilowatt-hours for agitating one million gallons of water 60 minutes. The lines in Fig. 8 are based on 10 kilowatt-hours per million gallons for 60 minutes mixing. It is believed that this is a liberal allowance for power. At least there is no reason why other basins might not be designed to be just as efficient as the Highland Park basins.

These figures do not indicate a great deal of difference in the cost of power for baffled basins and for mechanical mixing basins. At a velocity of 1.0 ft. per second in the Baltimore mixing basin, the head lost is about 1.6 ft. With electric current at 1 ct. per kilowatt-hour, the cost of power for mixing is about 8 ct. per million gallons. This velocity in the Baltimore mixing basin would give about 47 minutes mixing time. The cost of agitating one million gallons of water 47 minutes with mechanical mixers to produce a velocity of about 1.0 ft. per second also gives a power cost of about 8 ct. It looks as though for a given velocity of the water that the power requirement is about the same for mechanical mixing and mixing in horizontal baffled basins.

The writer wishes to express his appreciation for the very valuable information given by Jas. W. Armstrong and George B. Prindle.

References

[1]Hazen, Allen. The Filtration of Public Water Supplies. John Wiley & Sons, 1900.

[2]Fuller, Geo. W. Water Purification at Louisville. D. Van Nostrand Co., 1898.

[3]Stein, Milton F. Water Purification Plants and Their Operation. John Wiley & Sons, 1915.

[4]Hopkins, E. S. Experiments on Formation of Floc for Sedimentation. Eng. News-Record, 90: 204-5, February 1, 1923.

[5]Value of Chemical Mixing Conduit at Filtration Plant of St. Louis. Eng. & Contr., 49: 586, June 12, 1918.

[6]Hoover, Charles P. Mixing devices and reaction time. J. Am. Water Works Assoc., 11: 252-97, May, 1924.

[7]Smedberg, C. W. Loss of Head in Closely Baffled Mixing Basin. Eng. News-Record, 94: 476, March 19, 1925.

[8]Ellms, J. W. Operating and Tuning Up the Cleveland Filters. Eng. News-Record, 88: 776-9, May 11, 1922.

[9]Briedenback, E. H. Water Softening at Owensboro, Kentucky. J. Am. Water Works Assoc., 1: April, 1912.

[10]Alum Agitation Studies at Reading, Pa. Eng. News-Record, 93: 101-4, July 17, 1924.

[11]Kiersted, W. Sedimentation of Turbid River Water. Water Works, 63: 1268-75, June, 1925.

[12]Hatcher, M. P. Mixing and Coagulation in Water Works Practice. Water Works & Sewerage, 76: 435-6, October, 1929

[14]Ellms, J. W. Water Purification, Second Edition. McGraw-Hill Book Co., 1928.

Additional References That Contain Information on Mixing Basins

[14]Value of Chemical Mixing Conduit at Filtration Plant at St. Louis. Eng. & Contracting, 49: 586, June 12, 1918.
[15]Flint Water Filter Improvements and Reconstruction. Eng. News-Record, 84: 1189-91, June 17, 1920.
[16]Langelier, W. F. Coagulation of Water by Prolonged Agitation. Eng. News-Record, 86: 924-8, June 2, 1921.
[17]New Water Purification Plant for Topeka, Kansas. Eng. News-Record, 89: 153-5, July 27, 1922.
[18]Daily, C. M. Cleaning a Mixing Conduit of Lime Deposits. Eng. News-Record, 89: 695, October 26, 1922.
[19]Leisen, T. A. Detroit 320-M.G.D. Filtration Plant Is World's Largest. Eng. News-Record, 90: 860-5, May 17, 1923.
[20]New Water Purification Plant at Norfolk, Virginia. Eng. News-Record, 90: 824-5, May 10, 1923.
[21]Second Water Purification Plant for Dallas, Texas. Eng. News-Record, 90: 1042-4, June 14, 1923.
[22]Second Water Purification Works for Oklahoma City. Eng. News-Record, 93: 216-9, 1924.
[23]Schoonmaker, G. N. New Sedimentation and Coagulating Basins at Toledo. Eng. News-Record, 92: 443-6, March 13, 1924.
[24]Donaldson, W. Features of New Water Filtration Plant at Richmond, Va. Eng. News-Record, 93: 623, Oct. 26, 1924.
[25]Hill, N. S., Jr. New Filtration Plant at Tampa, Fla. Water Works, 65: 387-93, August, 1926.
[26]Spalding, C. H. Laboratory Reaction Apparatus Helps Operate Filters. Eng. News-Record, 96: 644-5, April 22, 1926.
[27]Wiedeman, H. F. Mixing basin at Atlanta Water Works. Eng. News-Record, 98: 874-5, May 26, 1927.
[28]Brown, C. A. Modern Methods of Water Purification. Water Works, 66: 337-8, August, 1927.
[29]Porter, J. L. New Ideas in Filter Plant Construction. Water Works, 66: 311-3, August, 1927.
[30]Kiersted, W. Settling Basin for Water-Works of Lawrence, Kansas. Eng. News-Record, 99: 65, July 14, 1927.
[31]New 12-M.G.D. Water Purification Plant of Oakland. Eng. News-Record, 98: 857-60, May 26, 1927.
[32]Mixing Chamber Being Added to Hannibal Filter Plant. Eng. News-Record, 100: 849, May 31, 1928.
[33]Burdick, C. R. New Pumping and Filtration Plant for Knoxville Water-Works. Eng. News-Record, 101: 204-7, Aug. 9, 1928.
[34]Mathews, W. W. Mechanical Agitators at Knoxville Water Works. Mun. News & Water Works, 75: 38, July, 1928.
[35]Jenks, H. N. Elements of Successful Coagulation. Water Works, 67: 203-6, May, 1928.
[36]Many-Purpose Water-Treatment Plant for Beverly Hills, Calif. Eng. News-Record, 102: 936-8, June 13, 1929.
[37]Veatch, F. M. Tulsa Building a 24-M.G.D. Water Purification Plant. Eng. News-Record, 102: 964-66, June 13, 1929.
[38]Langelier, W. F., and DeCosta, J. D. Operating Experiences with California Water Purification Plants. Mun. News & Water Works, 76: 53-7, February, 1929.
[39]Combined Aerator and Mixer Uses Injector Principle. Eng. News-Record, 104: 995-6, June 12, 1930.
[40]Levy, A. G., and Ellms, J. W. The Hydraulic Jump as a Mixing Device. J. Am. Water Works Assoc., 17: 1-26, Jan., 1927.
[41]Ellms, J. W., Hamlin, G. W., Levy, A. G., and Linders, J. E. A., Baldwin Filtration Plant, Cleveland Ohio. Proc. Am. Soc. Civ. Engr. 56: 201-60, February, 1930.

▼

Annual Meeting of North Dakota Water and Sewage Works Conference

The second annual meeting of the North Dakota Water and Sewage Works Conference was held at Grand Forks, N. Dak., Dec. 8th, 9th and 10th with more than 60 North Dakota water and sewage works officials in attendance. Delegates were present from all leading towns in the state. The conference was held in conjunction with the School of Engineering at the State University and the organization is particularly indebted to Dean E. F. Chandler of the School of Engineering for arranging a very fine program.

The annual banquet was held at the Hotel Ryan on the evining of December 9th. Mr. E. J. Thomas of Minot, was toastmaster, and Dr. R. P. Robertson of Wesley College of the State University, was the main speaker. Other speakers were Dean E. F. Chandler, School of Engineering, and H. E. Simpson, State Geologist.

The first day's session opened with a short business session which was followed by a paper by Mr. Lium, Grand Forks City Engineer, who explained the Grand Forks water supply and went into detail regarding the proposed improvements amounting to a total of $225,000. This was followed with papers by Professors P. W. Viesselman and O. H. Thormodsgard of the Law School, State University, who gave papers on "Municipal Liability for the Disposal of Sewage," and "Liability of municipalities for injuries resulting from furnishing impure water," respectively.

The main topic of discussion for the second day's meeting was the Missouri River Diversion Project and its affect on the water supplies in North Dakota. This subject was presented by W. P. Tarbell, City Engineer, Fargo, and H. E. Simpson, State Water Geologist. Other papers presented were: "Pressures for Fire Protection Dependent on Sizes and Looping of Mains," by Dean E. F. Chandler, School of Engineering; "Problems in Sewage Disposal," by Dean G. A. Abbott, School of Chemistry; "What is Potable Water," by Dean E. H. French, School of Medicine; "Operation and Control of Water Supplies and Sewage Disposal Plants for small Communities," by A. L. Bavone, State Sanitary Engineer.

In the afternoon, S. P. Ravnos, Waterworks Superintendent at Mandan, read a paper on "The Municipal Laboratory for Water Supply Control." This was followed by papers by C. G. Blough, School of Commerce and Finance, on "Methods of Customer Billing, and Accounting for Fixed Properties," and a paper by Irvine Lavine, School of Chemistry, on "Modern Methods of Water Softening." This was followed by a paper and movie film by C. S. Childs of The Flox Company, Minneapolis, on "Sodium Aluminate as a Coagulant."

The last day's session opened with a discussion of Operation, Efficiency and Cost of various types of pumps and pumping machinery, conducted by Professors N. T. Bourke and Alexis Diakoff of the School of Mechanical Engineering. This was followed by papers by H. E. Simpson, State Water Geologist on "Ground Water Supplies for North Dakota Cities," and by G. A. Johnson of Wallace Tiernan Company, who read a paper on "Recent Developments in the Field of Chlorination."

After the business session, the meeting commenced with an inspection tour of the Grand Forks water supply, state mill and elevator and sugar beet factory.

Among the resolutions adopted by the organization were resolutions supporting a proposed increase in the appropriation for carrying on the work of the state geologist, a resolution advocating an appropriation to maintain the Bureau of Sanitary Engineering of the State Department of Health and a resolution supporting a movement to standardize fire hose connections.

The following officers were elected for the coming year:

President, W. P. Tarbell, City Engineer, Fargo; Vice-President, F. W. Pinney, City Engineer, Jamestown; Secretary-Treasurer, A. L. Bavone, State Sanitary Engineer, Bismarck.

Fargo was chosen as the meeting place for next year.

An Electrodynamic Theory of Cyclones and Anticyclones

By HALBERT P. GILLETTE

IN previous issues of WATER WORKS AND SEWERAGE (October and November, 1930) evidence was presented showing that several ionized shells, beside the well known "Heaviside layer," surround the earth, and that the sun is similarly the core of several such shells. Since those shells presumably rotate in the same direction as their terrestrial and solar cores, they rotate anticlockwise, viewed from the north star. Rotation imparts magnetism to electrons (negative units) and peotons (positive units), as Rowland showed in 1876 with his experiments on charged disks that were rotated. It matters not whether an electron is attached to a whirling disk or a sphere, or is travelling through a solenoid. In either case magnetism results.

Ampere showed that electric currents flowing in the same general direction attract one another, whereas they repel one another when flowing in opposite direction.

If we couple Ampere's principle with one that Faraday discovered a century ago this coming August, we shall be able to explain the cause of all air-whirls and their analogs on the sun, or sunspots. Faraday ("Researches," I, p. 5) said: "As the wires approximated, the induced current was in the contrary direction to the inducing current. As the wires receded, the induced current was in the same direction as the inducing current. When the wires remained stationary, there was no induced current." This is Faraday's principle of induced currents. We now know that electrons actually flow through a conducting wire when a current exists in the wire. We also know that free electrons in a fluid, whether gaseous or liquid, are caused to move when moving electrons are brought nearer to them or are moved farther away, for the Faraday principle applies to electrons under all conditions.

Let us now consider what must happen to the free electrons in our atmosphere and in the earth's crust and beneath that crust, when a magnetic tide is caused in the Heaviside layer or in any other shell of electrons that encases the earth. In our last November issue the semi-diurnal, or 2-hour tide of the barometer and of electric potential gradients was explained by the magnetic effect of the sun's electron shells upon the earth's electron shells. If now we consider the Faraday induction effect of such a tidal wave, we shall understand how whirls are probably produced in the atmosphere.

Although there are evidently several electron shells, we may take any one of them, like the Heaviside layer, and use it to typify the magnetic action of the rest.

Just before dawn and just before sunset, the Heaviside shell has its semi-diurnal tidal crest. As the wave in this shell rises, the movement of the electrons is away from the earth, but since they are also rotating anticlockwise they induce a clockwise rotation in the free electrons below this shell. Since the velocity of the induced current will be greater the greater the velocity of the inducing current, and since the latter is greater in lower latitudes, it follows that the electrons in lower latitudes will acquire a greater increment in clockwise motion than those in higher latitudes. It can be easily seen that the effect of this is to create eddies in the free electrons of the lower atmosphere, the eddies whirling anticlockwise. These whirling electrons will carry air molecules with them, thus causing the anticlockwise whirls of air that are known technically as cyclones.

When the Heaviside shell moves earthward, as it begins to move after the crest of the magnetic wave has passed, a converse effect on the electrons in the lower air is produced, according to Faraday's induction principle. This explains the generation of the clockwise or anticyclonic air whirls in the northern hemisphere.

It is probable that similar cyclonic and anticyclonic whirls are generated in all the electron shells, and that those whirls in turn induce whirls in the lower atmosphere. This would seem to account for the rapidity with which violent tornadoes of small diameter develop.

There are several great "permanent cyclones," the two best known being the Aleutian cyclone and the Icelandic cyclone. Most of the storms that completely traverse North America are generated in the Aleutian cyclone.

It is significant that they usually have their origin south of its center, for if we apply Faraday's induction principle we see that it is in that region that the strongest eddies would develop. South of the center of this great stationary cyclone the air and electrons are moving eastward. In addition to the velocity due to the cyclonic whirl they have the velocity due to the earth's rotation. A similar condition probably exists for a great height above the earth's surface. Consequently when a wave in the Heaviside shell passes over this region, its ascent produces powerful retarding effects in the lower atmosphere, because of the Faraday induction. This would intensify the cyclonic eddies generated south of the center of the Aleutian cyclone, and would act conversely upon those north of that center. But on the contrary, anticyclonic eddies would be stimulated north of that center when the tidal wave in the Heaviside shell began to subside, and this would reach its climax at the ebb of that magnetic tide. Mr. Charles L. Mitchell has recently published in the "Monthly Weather Review," January, 1930, a very illuminating paper on the places of origin and the paths of cyclones and anticyclones. His charts show that the region northeast of the center of the Aleutian cyclone is where most of our anticyclones originate, whereas most of the cyclones that cross the continent originate south of that center, thus confirming the inferences above made.

Once an electron whirl has been started as an eddy it tends to develop into a whirling belt in which the electrons are most concentrated at some distance from the axis of the whirl. This results from Ampere's principle, for the adjacent electrons in the whirl are moving in the same direction and therefore attract one another magnetically. But since the electrons on opposite sides of the whirl are moving in opposite directions they repel one another, the whirl belt tends to increase its diameter. In this tendency to expand it is assisted both by centrifugal force and by the electric repulsion of the electrons. Opposing the expansion is the attraction that causes a moving electron to revolve about

the lines of force in a magnet. The whirling electrons constitute a magnet and many of its lines of force are along the axis, thus tending to restrain the outward escape of the electrons that are rotating about that axis.

The three most important characteristics of these whirls that remain to be explained are: (1) The ascent of air in cyclones and the descent in anticyclones. (2) The tendency of long-lived cyclones and anticyclones to attain an eastward motion. (3) The inward flow of air in cyclones and the outward flow in anticyclones.

Because of the free electrons in its whirling mass a cyclone is a magnet. It ascends because the magnetic pull of the upper electron shells upon the long whirling column of its electrons exceeds the downward pull of the earth's magnetic field. The ascent of the whirl tends to create a vacuum below, resulting in the inflow of surrounding air at the lower end of the ascending whirl. Friction and viscosity impart an initial whirl to the inflowing air; and, according to the principle of conservation of the moment of momentum, there results a rapidly increasing angular velocity of the air.

Conversely, since an anticyclone is rotating in the opposite direction it is pushed downward by the magnetic force of the upper electron shells. It is fed with inflowing air at its upper end, but at its lower end the air flows outward because the column of air "mushrooms" outward under the downward pressure against the earth. Being a whirl-belt the center of an anticyclone becomes "plugged up" at its lower end with air that flows inward as a result of the "mushrooming" process.

In a previous article I have explained the migration of cyclones and anticyclones as being due to a gyroscoping precession such as occurs in the spinning top of a gyroscope.

Although I have not yet completed my analysis of the intervals between the generation of cyclones and anticyclones, it seems clear that the most common interval is 5 days between successive cyclones and that the same is true of anticyclones. Also it seems to be the general rule that the anticyclones are generated about 2.5 days after the cyclones are generated. In *Water Works and Sewerage,* September, 1930, I pointed out that there is a sunspot cycle of 29.55 days and 1/6 thereof, these subcycles of about 5 days being apparently due to permanent solar whirls located about 60 degs. apart in longitude. Their magnetic action on the Heaviside shell would account for the frequent occurrence of 5-day intervals in cyclones and anticyclones and for the tendency of cyclones to alternate with anticyclones.

In several other articles I have shown that each planet causes not only a primary sunspot cycle slightly shorter than its orbital period, but a subcycle that is 1/6, 1/8 or 1/12 thereof. Since these magnetic cycles are very numerous, and since peaks of one sometimes aid, whereas their valleys sometimes oppose, the peaks of another cycle, simplicity of result is not to be expected.

▼

Fertilizer Sales Pay 68 per Cent of Operation Cost of Milwaukee Sewage Disposal Works

According to the 1929 report of the Common Council of Milwaukee, Wis., the operation and maintenance of the Milwaukee metropolitan sewerage system, including both collection and disposal of sewage, involved a net cost of only 66½ ct. per capita for the entire year of 1929. This does not include capital charges. A large reduction in the expense of the system has been effected by the sale of fertilizer called milorganite which is manufactured from the suspended solids removed from the sewage. The plant produced 34,933 tons of milorganite, almost 100 tons a day, and shipped 31,600 tons, for which an average price of over $20 a ton was received. The demand for fertilizer exceeds the Milwaukee output and is expected to continue to do so for many years.

About 70 per cent of the output is shipped to fertilizer manufacturers who blend it with other ingredients such as phosphates and potash and sell this product for use mostly in the states that grow cotton and tobacco. The remaining 30 per cent is sold for use directly without the admixture of any other material. This unmixed milorganite is especially valuable for the growing of fine lawns and for general garden use. Most of this part of the output goes to golf courses, park boards, and other places where fine lawns are maintained. A considerable amount is sold in 100-lb. bags to the gardeners of Milwaukee and the surrounding suburbs. These local sales in 1929 brought a return of approximately $10,000. The retail sale price is $1.50 per 100-lb. bag.

The plant treated from 85,000,000 to 1,000,000,000 gal. of sewage per 24 hours. During each day there is a peak load on the plant which amounts to from 130 to 140 million gallons in 24 hours. The total time of by-passing due to storms was 7.8 per cent of the total number of hours in the year. In other words, 92.2 per cent of all the sanitary sewage brought to the disposal plant during the year was purified, the balance being taken care of by dilution in the rivers and lake.

The cost of the plant operation only, not including any capital charges nor any part of the operation of the intercepting sewer system, in the city and the metropolitan district, is approximately $950,000 annually. At the present rate of production and the present price, the sale of the milorganite returns about 68 per cent of this amount. The profits realized last year totaled about $630,000.

▼

250 Cities Spend $1,036,000,000 for Improvements in 1928

The U. S. Department of Commerce has announced a summary of the financial transactions of the 250 cities having a population of over 30,000 for the fiscal year 1928.

The payments for operation and maintenance of the general departments of the city governments of the 250 cities for the fiscal period 1928 amounted to $1,853,232,348 or $42.63 per capita. In 1927 the comparaitve per capita for operation and maintenance of general departments was $40.98, and in 1917, $19.07. Payments for the operation of public service enterprises, as waterworks, electric light plants, and similar enterprises amounted to $164,154,462; interest on debt, $342,100,311; and outlays for permanent improvements, including those for public service enterprises, $1,036,635,298. The total payments in 1928, therefore, were $3,396,122,419; in 1927, $3,324,386,351; and in 1917 $1,108,021,565.

Of the total payments for outlays for permanent improvements, the principal items were $389,688,125, or 37.6 per cent, for highways; $178,675,794, or 17.2 per cent, for education; and $156,135,016, or 15.1 per cent, for public service enterprises.

Water Works and Sewerage

Published Monthly by
GILLETTE PUBLISHING COMPANY, 221 EAST 20TH ST., CHICAGO
Publishers of

Roads and Streets
Engineering and Contracting
Water Works and Sewerage
Motive Power
Tiles and Tile Work
Motor Freight
Road and Street Catalog and Data Book
Water Works Catalog and Data Book

HALBERT P. GILLETTE.....President and Editor
E. S. GILLETTE.....Vice-Pres. and Secretary
E. B. HOWE.....Vice-President
E. C. KELLY.....Vice-President
T. F. KILROE.....Vice-President
J. M. ANGELL, JR.....Eastern Manager
C. T. MURRAY.....Managing Editor
VICTOR J. BROWN.....Associate Editor
CHARLES M. NELSON.....Associate Editor
J. R. BAYLIS.....Associate Editor
A. E. KIMBERLY.....Associate Editor
L. H. ENSLOW.....Associate Editor
H. J. CONWAY.....Make-Up Editor
L. R. VICKERS.....Distributor News Editor

Cleveland Office.....953 Leader Bldg.
New York Office.....420 Lexington Ave.
San Francisco Office.....381 Bush St.

Subscription Price $1.00 Foreign Postage 65c Extra

Copyright, 1931, by Gillette Publishing Company

GOOD NEWS !

When prices of all commodities are meeting business conditions by increasing the buying power of the dollar, we believe that the readers of the Gillette publications are entitled to some consideration along this line.

All new and renewal subscription orders for WATER WORKS AND SEWERAGE will be entered from this date at the rate of $1.00 per year. This will allow you to double the purchasing power of your dollar and to secure this magazine at one-half the price charged for it for many years past.

All current subscriptions will be extended for the number of months equal to the unexpired term at the time of change of rate.

The Improbability of a Correct Inference from False Premises

IT is generally conceded that the only test of a scientific theory is that inferences deduced from it agree substantially with observed facts. Yet, by a curious twist, it has recently come about that the soundness of the ether theory is seriously questioned by several eminent scientists, in spite of the admitted correctness of many a scientific law based on the postulate that there is an ether that transmits radiant waves. Either it is not true that the test of a theory is its agreement with facts, or the eminent scientists have erred in rejecting the ether theory.

If agreement with facts is not the ultimate test of any theory, what test is there? Prediction that is verified by the subsequent occurrence of the predicted event? Well, that is only a special case of an agreement of a theory with a fact. Verified prediction has been called the most rigid test of a theory, and it is the very test that Einstein requested astronomers to make when he predicted that light rays passing near the sun would be deflected a certain amount. Yet Einstein is now counted among the physicists that doubt the existence of ether, in spite of the fact that the ether theory has also been proved true by the test of verified prediction, not only once but many times.

The problem in logic that we submit to our reader is this: May a scientist apply a certain sort of test of truth to his own theory and deny to another scientist the right to apply the same sort of test to some other theory?

It seems to us to be almost self evident that a scientific theory can be proved to be true only in one way, namely by showing that deductions from it agree so closely with facts not used in framing the theory that it is improbable that the observed degree of agreement would occur by accident. Jevons and other logicians have pointed out that precisely quantitative agreement between theory and observed fact never occurs. Jevons attributes lack of precise agreement partly to the imperfections of measuring instruments and partly to the existence of forces that interfere with the results that the theory leads one to expect. He mentions the failure of planets to travel in "exactly" elliptical paths, and points out that in physical measurements the term "exactly" means only a very close approximation to an assumed or deduced quantity. Since there is no possibility of precise agreement between a quantity deduced by aid of a theory, and a quantity measured by physical instruments, it follows that the rules of mathematical probability should be applied in every case where a theory is tested by an appeal to facts. Were precise quantitative agreement attainable, and were such agreement between theory and fact found, the odds would be infinity to one that the theory was correct. The odds obviously decrease as the divergence increases between a theoretically deduced quantity and the corresponding measured quantity; but it is worthy of note that the odds may still remain heavy in favor of the truth of a theory in spite of a considerable divergence of a measured quantity from the deduced quantity.

It may be argued that true inferences may be deduced from false premises, and that therefore agreement between a deduced result and an observed fact is not a perfectly reliable criterion of the truth of a theory. Such an argument, if valid, wipes out of existence a criterion of scientific truth that has had the support of every great physical scientist from Galileo to Einstein. While it is possible that an erroneous theory may lead to a correct inference, we know of no way in which this can occur except through an error in the process of deduction, such, for example, as an erroneous multiplication. Since an error of this sort is readily discoverable, its existence reaches the vanishing point when several independent experts have checked the processes of deduction. Granted that every expert may commit the same blunder in a given instance, the very rarity of such an occurrence is itself usable in a probability calculation as to the truth of the theory. Without having gathered all the known instances of such errors of deduction that were not immediately discovered by subsequent analysts, we can not state the odds against an error of this sort. We venture to guess that the odds are so many millions to one that for practical purposes we may say that, in any given deduction from scientific theory that has been checked by ten competent experts, there is practical certainty that the deduction is correct. If so, the premises must be substantially correct if the results deduced from them are in substantial accord with facts not used in framing the premises.

The failure of a theory or a law to agree "exactly" with certain facts to which it relates has often been

aid to discredit the theory. Thus Newton's theory of gravitation errs very slightly in not allowing for any change of mass of a planet due to a change of its orbital velocity; hence not a few scientists have erroneously argued that this discredits Newton's law of gravitation. It should be evident from the foregoing that to make such an inference is equivalent to disclosing lack of understanding of the principle that the truth of a physical theory or law is not absolute but relative. When a friend tells you that it is 10:15 A. M., he is not discredited when you show him that it is 10:15:10; nor would you be discredited if a split-second watch were used to give still greater accuracy in answering the question, "What time is it?"

▼

Four Major Business Depressions in 25 Years

THE first issue of ENGINEERING AND CONTRACTING was published in January, 1906. About a year later a major depression enveloped the business world—"the panic of 1907." Since then three others including the one now on its final lap, have occurred. In 1914, just before the world war, a depression set in that promised to be about the same as that of 1907. The war gave quite a different slant to it. The third depression of this series started early in 1920 and lasted about 18 months. The fourth started late in 1929, and is still in existence. This last one is of about the same intensity as that of 1920 in so far as unemployment is concerned but is of much less severity in many other respects. The depression of 1920 was characterized by the failure of many large corporations that were forced to sell large stocks of goods at much less than cost, due to the general deflation in commodity prices. The wholesale price index dropped 25 per cent in a few months in 1920, whereas during 1930 it declined much less and the decline was slow.

The depression of 1920 was marked primarily by a great and sudden decline in the prices of commodities, whereas that of 1929-30 was characterized by a great and sudden decline in the prices of securities, notably common stocks. Both panics, however, should probably be attributed primarily to the same cause, namely "over expansion" of certain facilities of production. During good times there is invariably a tendency to enlarge plants and increase other production facilities faster than is warranted by the growth of national income. Money is borrowed and stocks are sold to secure capital for such expansions. Later when it is found that the products of the enlarged plants can not be sold at a profit, a day of reckoning arrives. Then, shortly after the first shock to general confidence occurs, the ultimate consumers begin to make bad matters worse by curtailing their normal purchases. Unwise expansion of facilities of production is the first step toward trouble, followed by some spectacular crash that frightens the public, and then their panic leads to a severe curtailment of their normal purchasing. After a while it begins to dawn upon the public that the farmer was right when he replied to the question whether it would ever stop raining, by saying: "Well, hitherto it always has stopped." Normal purchases begin to be renewed, the skies brighten and another industrial storm soon ends. Perhaps the best way of bringing such a storm more quickly to its end is to disseminate the knowledge that a resumption of normal buying by the public has been the primary step in ending previous business depressions. But in order to reduce the number and severity of these depressions, it is essential to avoid over expansion of production facilities. This calls for careful analysis of the latent demand for each class of product, and a study of what one's competitors are doing in the way of expansion. It is not safe to plan one's own program of expansion without considering what one's competitors are doing along the same lines.

Accumulation of large surpluses from profits is often an incentive to over expansion. Instead of distributing nearly all profits in dividends retaining in cash and marketable securities only what is needed to tide over business slumps, many large companies invest a large percentage of their earnings in plant enlargements. This practice of "sowing profits back" is usually regarded as good practice, and, if held within bounds, it is. But it is often not thus held. Then the result is usually an over expansion that aids in creating a business depression. The otherwise laudable ambition of an executive to build a huge corporation as a monument to himself, thus becomes a factor in causing a business panic. Perhaps such factors are of much greater importance than we realize.

▼

Powdered Activated Carbon as Taste Eliminator

THE water works profession in the past contented itself with furnishing a pure water of good clarity to consumers. Today, there is a strong demand for a water possessing high potability.

No less an authority than Professor Jack J. Hinman of Iowa State University recently explained how important good taste and odor are to the water supply of a great hospital to which thousands of patents from far distant points come for treatment.

Although the water supply in such an institution might be perfectly safe, through proper chemical and bacterial control, the presence of an unusual "off" taste is certain to excite many patients unduly and perhaps dangerously. Even those of us outside of hospitals are not immune from dislike or even distrust and fear of ill tasting and smelling water.

Such pioneers in potability developments as John R. Baylis of Chicago have long recognized the especial application of activated carbon for this purpose and in this issue of WATER WORKS AND SEWERAGE E. A. Sterns, superintendent of the Hamburg, N. Y., Water Department, details his experiences with activated carbon when applied in a form requiring the very minimum of installation expense as well as simplicity and economy of operation. Other experiments at South Pittsburgh, East St. Louis, Olean, N. Y., and Hackensack, N. J., are reported where activated carbon has proved efficient in eliminating a wide range of taste and odor difficulties.

The application of powdered activated carbon is, however, so new that it will be most interesting to observe subsequent investigation of its possibilities in the water works field.

H. P. Gillette

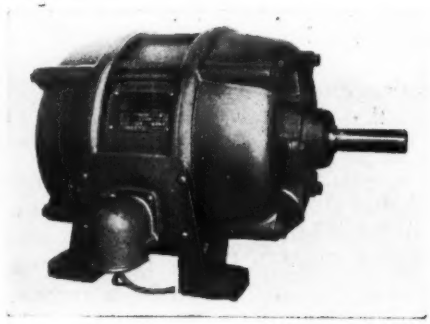
New Equipment and Materials

New Electric Motor

The Ideal Electric & Mfg. Co., Mansfield, O., has developed a complete series of electric motors, claimed to represent a radical departure from the ordinary type and design familiar to users of electrical power units. The new motors present many new design features of considerable interest. By placing the motor feet on the bearing brackets all load shocks and strains are carried directly to the motor support. Shock loads or vibration will not affect the live elements or weaken the assembly of the motor. Since the bearing brackets support themselves the only mechanical load on the stator is the motor torque. When the front end bracket and stator are removed, the pulley end bearing bracket remaining bolted to the base will still support the rotor and gear, pulley, or other connection to the driven machinery. This allows cleaning and examination in much less time than usual and without disconnecting the drive gear or pulley.

The motors are made as standard squirrel cage induction motors, slip ring induction motors and direct current motors in all types of mechanical construction and electrical characteristics. The squirrel cage induction motors are made in four standard designs as regards starting torques and starting currents. Special designs are made to suit any set of specifications.

All unit type motors are designed to meet the standard torques, power factors, efficiencies, heating specifications, dielectric tests and other performance guarantees and also the uniform mounting dimensions established by the National Electrical Manufacturers' Association. They are furnished in sizes from ½ to 200 hp.



Ideal 5 Hp., 1,800 Rpm. Ball Bearing Motor

New Boring Machine for Installing Pipe

The Hydrauger is a patented pneumatic-hydraulic auger. It has been used for several months with practical success in Marin County, California, and other parts of the San Francisco metropolitan area, demonstrating that it can bore under wide thoroughfares without the necessity for trenching. Automobiles have rolled unimpeded over the surface of the Redwood Highway, for instance, while the boring was being made beneath for the placing of 3-in. pipe. It is claimed that this machine will eliminate the tearing up of streets and highways for placing pipes and conduits.

The Hydrauger is notable in that an operator can direct its bore with the precision of a marksman, according to the manufacturer, at distances of 40 ft. bringing it out to within 2 or 3 in. of the point at which it is aimed. The machine is capable of boring at distances of 100 ft. or more without the necessity for trenching.

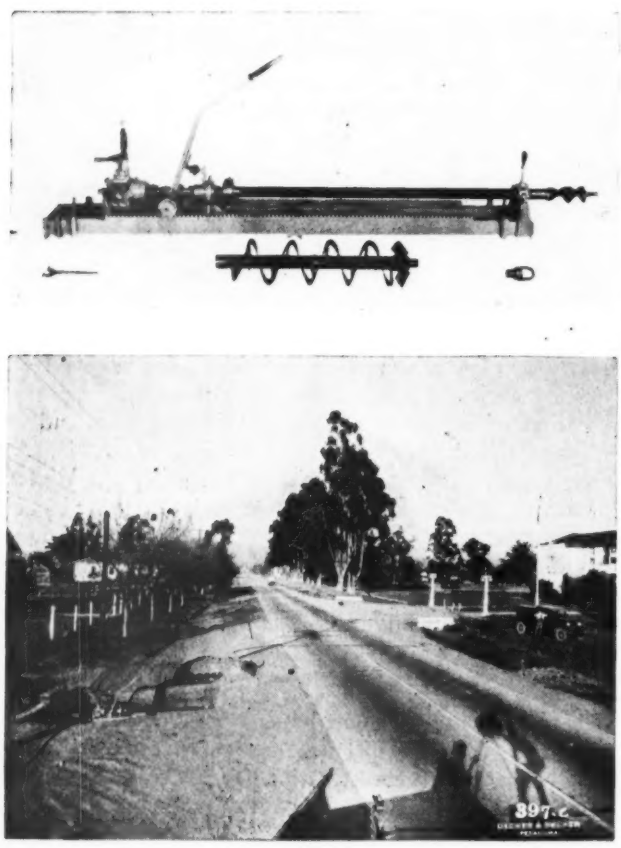
Not only does the use of the Hydrauger obviate the necessity for cutting up streets and highways, but it also is used for laying pipe under gardens and buildings, without disturbing the top soil

The machine is driven by compressed air and connected with running water, which passes through the boring-bars, issuing in two streams at the auger. The water washes the borings back, incidentally acting as a lubricant, and leaves a clean, straight hole. So little water is used that it can be obtained by connection with an ordinary domestic faucet or, if necessary, a fire hydrant. 30 lb. pressure is sufficient.

Where no piped water is available, water may be transported in a barrel and circulated by means of a small air-driven pump. So little water is used that it can be left in the ditch, or bailed out by the operators with small effort.

Feed ahead is accomplished by a simple and strong reversible ratchet. After a boring is completed the permanent pipe may be pushed in by hand or the machine ratchet may be used to pull in either the permanent pipe or a cable. A swivel is furnished with each machine for this purpose.

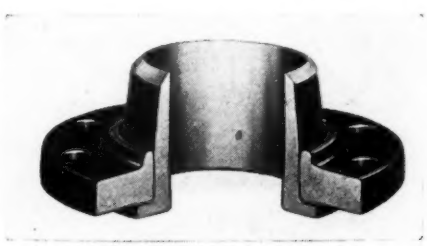
Public utility corporations and municipal engineering departments have manifested interest in the Hydrauger not only because of its time-saving advantages but also because of its value in cementing public goodwill. The machine has been developed by the Hydrauger Corporation, Ltd., 1298 Bryant St., San Francisco, Calif.



Above—The Hydrauger; Below—The Machine in Operation Installing Pipe Under a Street

New Flanged Joint

A new type of flanged joint has been developed for use in connection with welded pipe lines where such a joint is required for the insertion of valves and fittings for the taking off of outlets. It is known as the "Merco" swivel flange. It consists of a drop forged steel flange, fitted to a drop forge tapered nipple on which the flange may be rotated, permitting alignment of bolts, etc. The tapered nipple is forged from a solid steel billet and the finished product incorporates a thickness much greater than pipe at the base of the nipple where highest stress occurs. Being formed completely at the proper forging temperature, possibility of a fracture of the metal is minimized. The manufacturers state that by forging from a solid billet sufficient heat is stored up in the steel to permit operation being finished at the correct forging temperature.

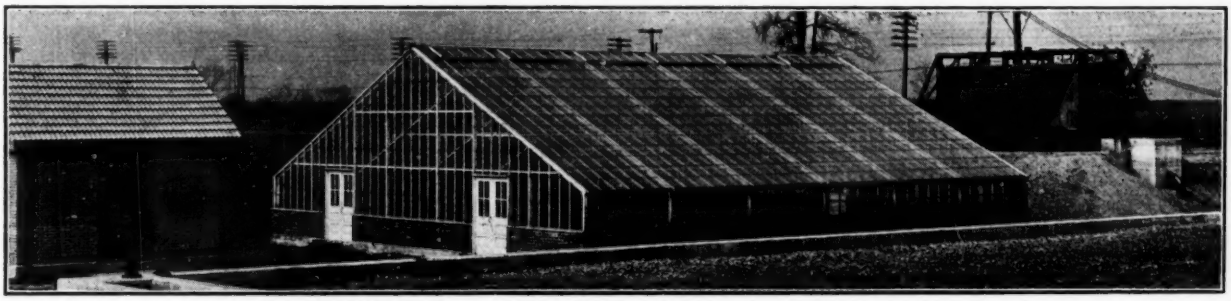


New Flanged Joint

An advantage of this swivel flange lies in its flexibility, having equally as much as the ordinary Vanstone type of flanged joint. The manufacturers are arranging production to soon make available sizes from 1½ in. to 10 in., and specifications are to meet the American standards in strength requirements.

This new product is made by the Merco Nordstrom Valve Co., 343 Sansome St., San Francisco, Calif.

KING ENCLOSURES REDUCE SLUDGE BED AREA 50%



Above: 51x51 ft. King enclosure built for Town of Cheektowaga, N. Y. Sewer District No. 3; Engineer, Geo. C. Diehl, C. E. Inc., Buffalo, N. Y. Contractor, W. L. Lose, Tonawanda, N. Y.

King—enclosed sludge beds require only 50 per cent of the area needed for open beds. Sludge can be removed at regular intervals without weather interference. Many more dryings are possible.

Numerous sewage plants have been equipped with King Sludge Bed Enclosures under the supervision of leading engineers.

All that we have learned in over twenty-five years of building glass-enclosures is at your disposal.

OUR CATALOGUE IS FILED IN SWEET'S

KING CONSTRUCTION COMPANY

533 Wheatfield Street

NORTH TONAWANDA, NEW YORK

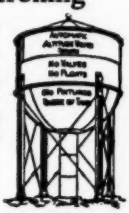
Schenectady, N. Y. Bridgeport, Conn. Philadelphia, Pa New York City
Scranton, Pa. Toledo, Ohio Boston, Mass.

WATER CONTROL

without floats or fixtures

A constant water level can be automatically maintained in reservoirs, tanks and standpipes by the use of

GOLDEN-ANDERSON Automatic Cushioned Controlling Altitude Valves



These valves are always cushioned in closing and opening. They are extensively used for automatically maintaining a uniform stage of water in reservoirs, tanks and standpipes. No valves inside. No floats or fixtures, inside or outside of tanks. No freezing troubles. Three ways of closing these valves:

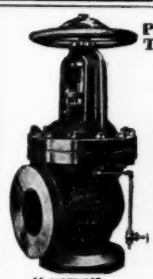
1st—Automatically, by water
2nd—By electricity, if desired
3rd—By hand

Remember: Valves cushioned at all times by air and water. No water hammer or bursting mains.

"Made with stop starter attachment for centrifugal pumps."

Golden-Anderson Valve Specialty Co.

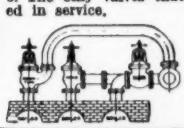
1329 Fulton Bldg., Pittsburgh, Pa.



Pat. Automatic Double Cushioned Triple Acting Non-Return Valves

1. Prevent shut-downs due to reversal of steam flow.
2. Instantly close and isolate a boiler when a tube bursts.
3. Cut off steam flow from every boiler instantly when a steam pipe ruptures.
4. Automatically cut a boiler into line.
5. Prevent backflow into cold boiler.
6. The only valves that can be tested in service.

"4575"
Used by Steel Companies



Angle, Globe or Elbow

Patent Automatic Cushioned Controlling Float Valves

They carry a constant water level in feed water heaters by perfectly controlling the flow of makeup water.

Operated by protected enclosed copper float.

Cushioned by both air and water. Operate without hammering, sticking or chattering. No metal-to-metal seats. Made angle or straightway.

Sizes 1 in. to 24 in.

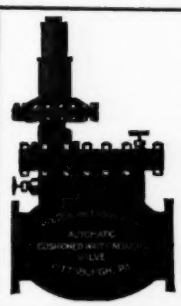
Pat. Automatic Double Cushioned Check Valves

1. Especially adapted for water service.
2. For high or low pressure.
3. Thoroughly cushioned. No chattering, hammering, or sticking.
4. Globe or angle patterns up to 24 inches.
5. Especially adapted for hydraulic elevator service.

Pat. Automatic Cushioned Water Float Valves

1. Automatically maintain uniform water levels in tanks, standpipe, etc.
2. Instantly adjusted to operate quickly or slowly.
3. Floats swivel to any angle—most satisfactory float valves known.
4. No metal - to-metal seats—no water hammer or shock.
5. Cushioned by air and water.

Sizes ¾" to 24".



Pat. Automatic Cushioned Water Pressure Regulating Valves

1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly cushioned by water and air. No metal-to-metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required—No attention necessary.
5. Positively no hammering or sticking. Sizes to 24 in.

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

Meter No. 1,000,000 Not "Just Another Meter" to Badger Company

C. W. Wright, president of the Badger Meter Manufacturing Company of Milwaukee, Wisconsin, knows about most everything that goes on in the plant of which he is the head, but from a day in June, 1930, to a day in December a certain piece of business was going on which was known to every member of the organization except the president.

A water meter destined to be plated with gold and mounted under glass on a walnut pedestal was authorized for assembly by the meter register. To produce this more than ordinary meter under the nose of the president, so to speak, a secret plan was worked out. The parts were selected from production line stock, and the millionth meter was assembled and tested. To give it special dignity and preserve its color it was gold plated. The mounting and inscription plates were prepared, one for the pedestal and one for the meter.

In December Mr. Wright was let in on the secret. Meter No. 1,000,000 was presented to him with the compliments and good wishes of his entire organization. A written testimony to the leadership and inspiration of Mr. Wright, which had made possible the company's progress, and stressing the respect felt for him by the organization was signed by men from every department, those who could not attend the presentation sending their signatures by proxy and their good wishes by letter and telegram. In order that every one might have an actual part in the gift, the cost of the historic meter was prorated among the entire organization.

C. W. Wright, President, Badger Meter Mfg. Co.

The inscription plate on the meter itself carried the words: "Presented to C. W. Wright, president, by Badger Meter Manufacturing Company Organization, December, 1930."

Luke L. Ballard, sales manager of the company, told of its humble beginning in 1905, of its slow but steady growth during the next 15 years, and called attention to the fact that Meter No. 1,000,000 was manufactured during the company's silver anniversary year. A single order for 5,000 meters in 1919 was said to be the stimulus which spurred the company on, until a new and modern plant was erected in Milwaukee and branch offices came into being in New York, Cincinnati, Savannah, Kansas City, Los Angeles, Waco and Seattle.

In addition to the cold water line of meters which has been enlarged until it is said to be one of the most complete in the industry, great progress has been made with meters for the gasoline industry and other industrial uses.

To Mr. Wright the millionth Badger meter represents more than a milestone in the progress of the company, for back of it are the good wishes, the respect and the admiration of his entire organization.

Badger's Symbol of Admiration for Their President

Gorman Joins Pardee Engineering Co.

Arthur E. Gorman, who has been active for many years in the affairs of the American Water Works Association and the American Public Health Association has resigned his position with the Wallace & Tiernan Company of Newark, N. J., to become sales representative for the Pardee Engineering Company, Inc., of Long Island, N. Y., according to recent announcement.

At the annual meeting of the stockholders of the Pardee Engineering Company, manufacturers of chlorine and ammonia control apparatus, Mr. Gorman was elected a member of their board of directors. He will have charge of the territory west of the Allegheny Mountains, where it is stated he will represent several other well known manpfacturers of water works equipment. His headquarters will be located in the Engineers Building, Chicago.

Mr. Gorman was at one time chief sanitary engineer in charge of chlorination control for the City of Chicago. In 1928 he was awarded the "Diven Medal" by the A. W. W. A. "as the member who has best served the Association during the year." He has been a member of the water works practice committee for several years and in 1930, as chairman of the membership committee, directed the campaign which brought nearly five hundred new members into the association during the year.

In 1928, Mr. Gorman was chairman of the Public Health Engineering Section of the A. P. H. A. and also vice-chairman of the Illinois Section of the A. W .W. A.

Pomona Pump Sales in 1930 Show Big Increase

W. H. Day, vice-president of the Pomona Pump Company located at Pomona, Calif., reports sales during 1930 of 40 per cent more than 1929 and a quota of greater sales is made for 1931. It is stated that a policy of straight line production will be maintained by the factory and stocks of practically every capacity pump head will be available for immediate delivery by express or freight.

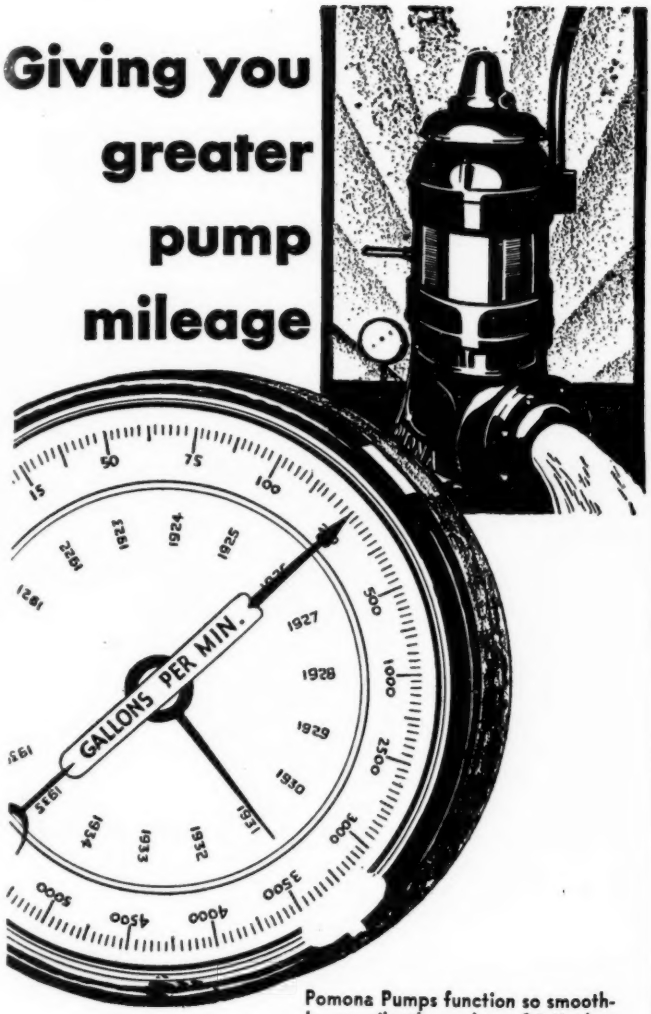
Announcement is made by Mr. Day of the appointment of R. L. Nourse as direct factory representative of the company for the Chicago district, assisting C. C. Cook. Mr. Nourse will put into immediate effect plans for developing new business in the midwest for Pomona. It is stated that the company now has direct factory representation in every key city throughout the country.

Kenneth G. Sites Enters Water Works Field

Kenneth G. Sites, who has for the past two years been associated with Picard-John, Inc., as contact and selling representative of their New York advertising agency, has joined the sales organization of the Hydraulic Development Corporation, according to recent announcement. He has been making a study of the product of this company, Hydro-Tite, at the factory in Boston and the main sales office in New York, and has been assigned territory in New York, New Jersey and Pennsylvania.

Mr. Sites attended high school at Great Neck, L. I., and completed his education with four years at Wesleyan University.

Giving you greater pump mileage



Pomona Pumps function so smoothly, so silently and so frictionless that they are adding daily to greater pumping progress and making possible new standards and records wherever water is lifted. Strength and simplicity of parts materially reduces the cost of maintenance and correspondingly increases its reliability. Vitally important exclusive Pomona features are: Goodrich Cutless bearings, built-in Westinghouse motors, semi-open impellers, non-corrodible stainless steel pump shaft, adjustable pumping capacity and straight water passage through pump stages.

MORE GALLONS PER KILOWATT

MORE YEARS PER BEARING

MORE SATISFACTION PER PUMP!

Distributors, factory representatives and service facilities in all principal cities. Name of nearest one and bulletin on request.

POMONA PUMPS — Ocean of Water

Pomona Pump Co., Pomona, Calif.

POMONA

WATER LUBRICATED

TURBINE PUMPS

TURN YOUR BACK ON RUST TOO...

When McWane 1¼, 2, or 3 inch cast iron pipe goes in, the chance for future trouble with rust goes out.

Every water works man knows that cast iron pipe cannot rust. But many of them overlook the fact that they can now use McWane Cast Iron Pipe for everything above 1 inch.

CAST IRON NOW COSTS LESS

The new long laying-lengths in which McWane Cast Iron Pipe in small sizes now comes, are shown above. They make laying McWane small pipe as fast as laying any other pipe.

Nor are skilled pipe-fitters required to handle.

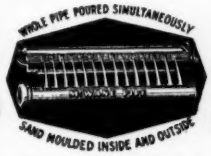
The cost per year of cast iron is lower than for perishable pipe—because you only lay it once. First cost is last cost.

Get new McWane Small Cast Iron Pipe booklet *today*.

LARGER SIZES TOO

McWane Cast Iron Pipe comes as large as 12 inches. B. & S. Type. With or without Precalked Joints. Standard lengths, and SAND CAST. Write or wire for prices.

McWANE CAST IRON PIPE CO. BIRMINGHAM ALABAMA



PACIFIC STATES CAST IRON PIPE CO. PROVO, UTAH

Chicago: 208 S. LaSalle St. Philadelphia: 123 S. Broad St.
Dallas: 1807 Santa Fe Bldg. San Francisco: 111 Sutter St.

An Enviable Record

Every industrial plant in the country no doubt is striving to attain a record of operating throughout the year without an accident resulting in lost-time.

The Pittsburgh plant of the Universal Atlas Cement Company, a subsidiary of the United States Steel Corporation, which employs more than 500 men and has a producing capacity of nearly 20 million sacks of cement a year, did attain such a record for 1930, according to a recent announcement. This is said to be the largest cement plant in the country ever to win the annual safety trophy offered by the Portland Cement Association.

Two delegates from the plant and representatives from other companies that won similar trophies will form a party to be conducted by the association to Washington, where President Hoover will be invited to make the awards.

The Pittsburgh plant started on its present record September 3, 1929, so that its record is for 484 continuous days without accident. R. L. Slocum is superintendent of the plant and J. R. Cline assistant superintendent. Aiding them in safety work is E. H. Loveday. Gordon Huth is safety director for the entire company.

Previous to last March E. D. Barry was superintendent of the plant for eighteen years. He is now assistant operating manager of the company, and in commenting recently stated: "Temperatures in the kilns of the cement plant reach almost 3000 degrees, a greater heat than that required to melt steel. Heavy grinding and pulverizing machines abound with potential danger for the worker. Yet our modern mechanical safeguards, plus a continuous program of safety education, so protect the employees that there has not been a serious machinery accident in recent years."

General Electric Announces Executive Changes

Following a recent meeting of the board of directors of the General Electric Company, Gerard Swope, president, announced the election of T. K. Quinn of Cleveland and Charles E. Wilson of Bridgeport as vice-presidents; H. H. Barnes, Jr., of New York as commercial vice-president in charge of the New York district, and J. L. Buchanan of Bridgeport, president of the General Electric Supply Corporation. The resignations of Charles E. Patterson and Cummings C. Chesney were included in the same announcement.

P. B. Zimmerman will succeed Mr. Quinn at Cleveland and J. W. Kewley will act as manager of the incandescent lamp department. T. W. Frech has been extended another year's leave of absence to continue his work as head of the RCA Radiotron Company at Harrison, N. J.

Mr. Quinn's headquarters will be located at 120 Broadway, New York City. In addition to heading the refrigeration department he will serve as chairman of the G. E. Appliance committee, composed of J. E. Kewley, C. E. Wilson, P. B. Zimmerman and G. A. Hughes.

Dayton-Dowd Company of Quincy, Ill., is now being served throughout the State of Arizona by J. B. Downey as district sales representative. Mr. Downey's office is located at 8944 North Second St., Phoenix, and he will represent the entire line of centrifugal pumping equipment put out by the manufacturer.

Innocent Bystanders

Little did they know that their pictures were being taken as they recently stood back out of a crowd to view from a distance a tractor equipped with pipe handling boom. But here they are! The camera reporter presents L. E. Dauer, sales manager of the Trackson Company, Milwaukee, and J. W. Ferris of the Ferris Tractor Company, Dallas, Tex. One of them is a long ways from home.

Aeroil Burner Appoints Field Sales Manager

Herbert M. Orschel, who has had many years' experience in industrial oil burning equipment, has been appointed Field Sales Manager for the Aeroil Burner Company, Inc. The main office and works of this company are located at West New York, N. J., and branch offices are maintained at Chicago and San Francisco.

It is stated that Mr. Orschel will travel extensively throughout this country and Canada and increased activities are anticipated by the company as a result of his personal contacts.

Included among the products put out by the Aeroil Company are asphalt tar and pitch kettles, paving tool heaters, thawing torches and outfits, sewer pipe compound heaters, lead melting furnaces, oil-burning salamanders, disinfecting torches, asphalt surface heaters, etc.

Announcement

W. Spencer Robertson, president of the General Water Treatment Corporation, recently issued an announcement to the effect that that company had been effected by the exchange of over ninety per cent of the outstanding capital stock of The Permutit Company for stock of the General Water Treatment and the acquisition of all the capital stock of Ward-Love Pump Corporation.

Through its subsidiaries it is stated that the General Water Treatment Corporation will engage in the manufacture and sale of water systems and equipment and minerals for the softening, purification or other treatment of water.

The directors of the company are Francis N. Bard, Vincent Bendix, Harry M. Durning, William M. Flook, W. Spencer Robertson and Kenneth B. Schley. The officers are Francis N. Bard, chairman of the board; W. Spencer Robertson, president; Harry M. Durning, vice-president; and H. W. Pratt, secretary and treasurer.

Personnel Items from Link-Belt, Limited

Manitoba Bridge & Iron Works, Ltd., of Winnipeg, has been appointed to represent Link-Belt, Limited, in the provinces of Manitoba and Saskatchewan, according to a recent announcement of E. C. Burton, vice-president of the company. Officials of the Manitoba company are: H. B. Lyall, vice-president and general manager; J. A. McCulloch, assistant to the vice-president; H. A. McKay, chief engineer; K. B. Schiller, sales manager. This company maintains sales offices in Calgary and Regina, operating foundries, structural and machine shops, and rolling mills, and is said to be in excellent position to render excellent service.

In Southern Alberta Link-Belt will be represented by Riverside Iron Works, Ltd., of Calgary. F. L. Irving is manager of the company; R. H. Findlay, chief engineer, and R. A. Millar, sales manager.

Announcement

Hugh W. Skidmore and Gene Abson, directors of that old firm of consulting and inspecting engineers which has been known for the past twenty years as the Chicago Paving Laboratory, announce the adoption of the title Chicago Testing Laboratory, Inc., as a more inclusive name for describing the field of their activities.

This firm does not wish to abandon the old name which has come to mean much to them for so long a time, so the new title is an addition rather than a substitution and old friends will hereafter find them listed as Chicago Testing Laboratory, Inc., and affiliated Chicago Paving Laboratory, Inc. The change is in name only as the same personnel, equipment and location continues to serve.

The consultation services offered by this organization covers: Investigation; reports; specifications; design; physical and chemical testing; research and laboratory, plant and job inspection of pavements, structures and works.

"Number, Please!"

Laying a pipe line for telephone conduit under the Hutchinson River from the Boston Post Road on the east to East 233rd St. on the west, the pipe totaling 497 ft. in length is one of the interesting feature stories told in a recent issue of *The U. S. Piper,* the attractive quarterly published by The United States Pipe and Foundry Company of Burlington, N. J. The probable outlay for construction, improvements and developments of the component companies of the Bell System of the United States for 1930 was given in *The Piper* as $700,000,000.

Pomona Pump Company of Pomona, California, announces the assignment of Harry P. Hart as direct factory representative of the Pacific Northwest territory. This is for the purpose of bringing about a closer cooperation between the factory and the many Pomona water-lubricated turbine pump distributors located in Oregon, Washington, Idaho and British Columbia. Mr. Hart is well known in the irrigation districts of California because of his many years of association with the turbine pump business. He will maintain headquarters at 1915 31st Avenue, South, Seattle.